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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G06F 15/74	A1	(11) International Publication Number: WO 92/14216
		(43) International Publication Date: 20 August 1992 (20.08.92)

(21) International Application Number: PCT/US92/00721

(22) International Filing Date: 29 January 1992 (29.01.92)

(30) Priority data:
647,774 30 January 1991 (30.01.91) US

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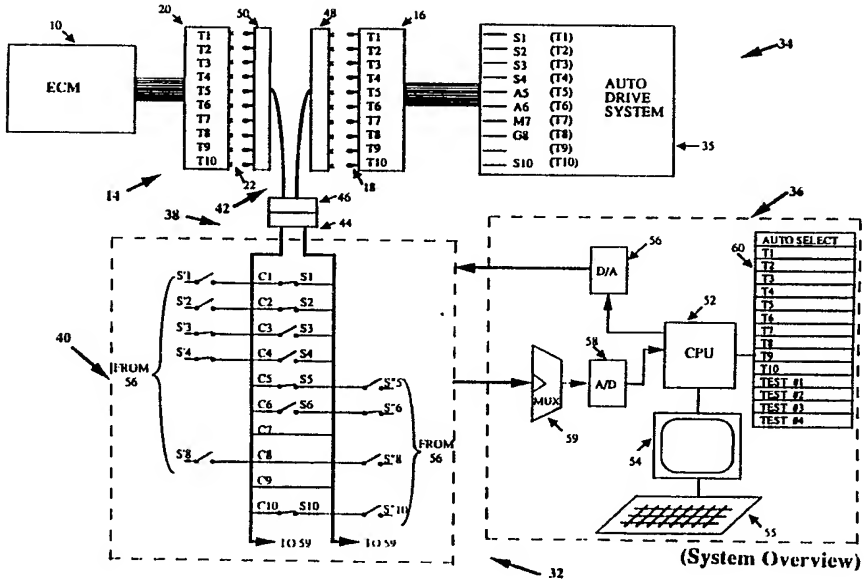
(81) Designated States: AT (European patent), BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), MC (European patent), NL (European patent), SE (European patent).

Published
With international search report.

(54) Title: INTERACTIVE DIAGNOSTIC SYSTEM FOR AN AUTOMOTIVE VEHICLE, AND METHOD



(57) Abstract

This interactive diagnostic system provides the automotive service professional with all of the tools necessary to provide precision diagnostic testing on today's computer-controlled cars. This is accomplished by providing the system with means including an external computer (36) for controlling operation of one or more specific actuators independent of the onboard computer (10) and for simulating the operation of these latter sensors. At the same time, the electronic data entering and exiting the onboard computer (10) including the actual data associated with the network of sensors and actuators (12) can be continuously monitored and analyzed by the external computer (36).

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INTERACTIVE DIAGNOSTIC SYSTEM FOR AN AUTOMOTIVE VEHICLE, AND METHOD

The present invention relates generally to a diagnostic system for an automotive vehicle of the type having (1) a network of sensors and actuators for independently sensing and actuating a number of different functions within the vehicle and (2) an onboard computer for monitoring the sensors and controlling the operation of the actuators. The present invention relates more particularly to what may be referred to as an interactive system for diagnosing the performance of a vehicle (1) by controlling the operation of one or more of its specific actuators independent of its onboard computer, (2) by simulating the operation of one or more of its specific sensors independent of the actual operation of those sensors, and (3) by continuously monitoring and analyzing the other vehicle actuators and sensors and, in fact, all of the electronic data entering and/or exiting the onboard computer, preferably, in real time.

It is a fact that most new cars and trucks, that is, automotive vehicles generally, are far more sophisticated than their predecessors. As exemplified in Figure 1, a typical vehicle manufactured today, generally indicated at 8, includes an onboard computer 10 which is generally

referred to as an electronic control module. This ECM serves to control the operation of one or more specific actuators associated with the vehicle's auto drive system 12 including its engine and other components by responding to the network of corresponding sensors. Typical actuators which are usually solenoids, although not always, might include fuel injectors, an air diverter valve, an ignition module, valves associated with anti-lock brakes, as well as others, some of which are illustrated in Figure 1. Typical sensors may include temperature sensors, oxygen level sensors, sensors associated with anti-lock brakes and so on, some of which are also illustrated in Figure 1. The way in which these components interrelate with one another and with the electronic control module may be best exemplified by the way in which fuel injection is controlled as a function of oxygen levels within the engine. More specifically, the ECM uses an oxygen sensor in the exhaust manifold to sense the oxygen level there and, at the same time, it operates the fuel injector through an associated solenoid. Thus, if the ECM senses an increase in oxygen, it will automatically increase fuel consumption by appropriately operating the fuel injection solenoid and, if it senses a decrease in oxygen, it will automatically decrease fuel consumption by means of the same solenoid, thus achieving optimal emission levels.

Still referring to Figure 1, a typical arrangement 14 for electrically connecting the ECM 10 with its network of actuators and sensors 12 is illustrated. This connection arrangement includes an auto-side connector 16 having a series of auto-side plug-in terminals 18 respectively connected with associated sensors and actuators and a computer-side connector 20 disengageably connectable to the auto-side connector by means of corresponding, complementary computer-side plug-in terminals 22 connected to the

appropriate circuitry within electronic control module 10. In the embodiment illustrated in Figure 1, the auto-side terminals 18 are shown as the male terminals and the computer-side terminals 22 are shown as female terminals. For purposes of clarity, cooperating terminals 18, 22 are designated T1, T2, T3 and so on. Only ten such terminals have been illustrated for purposes of convenience but in today's vehicles, there can be as may as 100 such terminals. The components connected with these terminals vary between different vehicle makes and models. For example, the oxygen sensor might be associated with terminal T1 in one vehicle and T5 in another. Vehicle makes and models may include sensors and actuators that other vehicle makes and models do not have. For example, a knock sensor used to sense engine knocks, which result in the ECM retarding spark timing, is found generally only in more expensive cars.

Having described the present-day high tech automotive vehicle, attention is now directed to one prior art way in which it can be serviced. Specifically, the automotive service professional might use what is commonly referred to as a "breakout box", generally indicated by the reference numeral 24, for gaining access to all of the terminals T1-T10. To this end, the breakout box has its own adaptor 26 disposed between and connecting together auto-side connector 16 with computer-side connector 20 such that each terminal 18 remains connected to its associated terminal 22. At the same time, adaptor 26 is connected to the breakout box through a connecting harness 28 for electrically connecting the breakout box's own terminals 30 to corresponding terminals T1, T2, T3 and so on. In this way, the automotive service professional can easily gain access to any of the terminals T1 - T10 by means of terminals 30.

In actual practice, the breakout box 24 is typically used by the automotive service professional to diagnose a problem associated with energization of a trouble light on the dashboard of the vehicle in question. Many vehicle makes and models include their own trouble code associated with each given trouble light. Typically, a trouble code indicates some abnormal condition in a given circuit within the vehicle's electronic system. For example, trouble code 42 on a GM vehicle may indicate abnormal voltage readings from the oxygen sensor. Thus, on a vehicle with code 42 set, a professional may connect the breakout box 24 and insert a voltmeter into the terminal associated with the oxygen sensor on that particular vehicle, say terminal T^5, and verify the actual voltage in the circuit. It is worthwhile noting that whereas some trouble codes are very specific, others are quite general and in many cases the same code will be set for many different problems; further more, many problems will cause the setting of multiple trouble codes.

It is important to note that the diagnostic system associated with the breakout box 24, as described above, is a passive system. That is, the automotive service professional uses the breakout box to access the connector terminals in order to observe the components associated with those terminals typically by connecting a volt meter and from those observations, he is hopefully able to diagnose the problem.

There are a number drawbacks associated with the passive diagnostic approach just described utilizing breakout box 24. One obvious drawback relates to the time it takes to make the diagnosis. An appropriate manual for each given vehicle make and model must be kept and reviewed in order to determine which terminals to access and what to look for,

depending upon the particular trouble light that is flashing and the particular vehicle. In many cases, the trouble that is described by the vehicle operator does not always result in a flashing trouble light or the trouble is intermittent and does not always occur at the time the vehicle is being diagnosed. After an extended diagnostic period, the problem may not be found or its results suspect. Moreover, the problem may only occur under certain conditions that cannot be duplicated at the service station. For example, evaluating problems associated with the air management system often require that the vehicle's engine be under load. Of course, this is not possible using breakout box 24 without actually driving the vehicle.

In view of the foregoing, it is a general object of the present invention to provide a state-of-the-art diagnostic work station designed to provide automotive service professionals with all the tools necessary to perform precision diagnostic testing on today's computer-controlled engines, anti-lock brakes and other such components, as discussed previously in conjunction with Figure 1.

A more particular object of the present invention is to provide a diagnostic work station which utilizes its own external computer for continuously monitoring, preferably in real time, and analyzing electronic data entering and/or exiting the onboard computer of the vehicle being diagnosed including actual data associated with the vehicle's network of sensors and actuators.

Another particular object of the present invention is to provide a state-of-the-art diagnostic work station that takes an interactive role, which means that it is not only capable of analyzing the electronic data entering and/or exiting the onboard computer, but it is also capable of

controlling the operation of one or more specific actuators independent of the onboard computer and simulating the operation of one or more specific sensors, independent of the actual operation of these sensors, as contrasted with the previously described breakout box 24 which merely takes a passive role.

Still another particular object of the present invention is to provide a state-of-the-art diagnostic work station that is rapidly and easily adapted for use with different vehicle makes and models.

As will be discussed in more detail hereinafter, the particular diagnostic work station, actually system, disclosed herein is specifically designed for high technology automotive vehicles of the type described in conjunction with Figure 1. Thus, it is designed for use with a vehicle including (1) a network of sensors and actuators for independently sensing and actuating a number of different functions within the vehicle, (2) an onboard computer for monitoring the sensors and controlling operation of the actuators, and (3) cooperating auto-side and computer-side connectors having cooperating auto-side and computer-side plug-in terminals for electrically connecting the onboard computer with the sensors and actuators, again as described previously in conjunction with Figure 1.

In accordance with one aspect of the present invention, the particular diagnostic work station disclosed herein utilizes means including its own computer arrangement separate from the vehicle's onboard computer, for continuously monitoring and analyzing in real time electronic data entering and/or exiting the onboard computer, that is, the ECM, including actual data associated with the vehicle's network of sensors and actuators. Thus, using the monitor

in association with the external computer arrangement, the outputs of a number of related sensors can be simultaneously observed visually while, at the same time, the operation of associated actuators are monitored.

In accordance with another, more complex aspect of the present invention, the diagnostic work station disclosed herein includes a series of components that cooperate with its external computer for allowing the work station to interact directly with the vehicle's network of sensors and actuators and its onboard computer. This is accomplished first by providing suitable means for selectively and temporarily disconnecting one or more specific sensors and/or one or more specific actuators from the vehicle's onboard computer. At the same time, the work station's external computer arrangement is temporarily connected with these latter sensors for simulating the action of each one independent of its actual operation and also connected to these latter actuators for controlling the operation of each of these actuators independent of the onboard computer. At the same time, some of the other sensors and actuators, that is, those not disconnected from the vehicle's onboard computer, can be continuously monitored and analyzed by the external computer. Thus, if it is necessary to observe certain vehicle functions at high altitude or under high or low temperature conditions, using the diagnostic work station disclosed herein, it is not necessary to move the vehicle to a location of high altitude or to subject the vehicle to high or low temperature conditions. Rather, all that is necessary is to disconnect the appropriate barometric and temperature sensors from the vehicle's onboard computer and, using the external computer arrangement, simulate the way the sensors would operate at high altitude and at high or low temperature conditions so that the onboard computer thinks these latter conditions exist. The onboard computer

will then operate the rest of the vehicle functions as if that were the case and these latter functions can then be monitored and analyzed by the external computer under these simulated conditions.

Whether the diagnostic work station disclosed herein merely serves a passive role of continuously monitoring and analyzing the vehicle in question or actually interacts with the vehicle, as described briefly above, it is readily and rapidly adaptable for use with vehicles of different makes and models. This is because, although different vehicle makes and models include different sensors and/or actuators and different onboard computers, the work station's external computer is provided with a database for distinguishing between these differences.

Other, more detailed features of the present invention will become apparent from the following detailed description in conjunction with the drawings, wherein:

FIGURE 1 diagrammatically illustrates, partially in block-diagram, a diagnostic system designed in accordance with the prior art for use with high-technology automotive vehicles;

FIGURE 2 is a diagrammatic illustration, partially in block-diagram, of a diagnostic work station for similar high-technology vehicles , but one which is designed in accordance with the present invention; and

FIGURE 3 is a diagrammatic illustration of a particular feature of the work station in Figure 2.

FIGURES 4 and 5 are further diagrammatic illustrations depicting the way the system functions.

Turning now to the drawings, attention is immediately directed to Figure 2, inasmuch as Figure 1 has been discussed previously. Figure 2 illustrates a diagnostic work station 32 which is designed in accordance with the present invention to provide automotive service professionals with all the tools necessary to perform precision diagnostic testing on today's high technology vehicles. One such vehicle, generally indicated by the reference numeral 34, is diagrammatically illustrated in Figure 2 and corresponds to the vehicle described heretofore in conjunction with Figure 1. Thus, vehicle 34 includes among other components, an entire auto-drive system 35 which itself includes an engine, transmission, brakes, and so on, as well as a network of sensors and actuators associated with these latter components. For purposes of convenience, the sensors and actuators are indicated by the letters S and A with numerical subscripts distinguishing one from the other. Vehicle 34 also includes an onboard computer, specifically the same electronic control module 10 and arrangement 14 for electrically connecting the ECM with the sensors and actuators as described in conjunction with Figure 1. It may be recalled that arrangement 14 includes an auto-side connector 16 having its own auto-side plug-in terminals 18 and a computer-side connector 20 including its own computer-side plug-in terminals 22. For purposes of convenience, only ten terminals are illustrated, specifically terminals T1-T10. Most of these terminals connect associated sensors or actuators with appropriate circuitry at ECM 10. For example, terminal T1 connects ECM 10 with sensor S1, terminal T2 connects the ECM to sensor S2, and so on. The particular components M7 and G8 illustrated as part of the auto-drive system and connected to the ECM through terminals T7 and T8 will be described hereinafter along with the function of terminal T9.

Having again described the necessary components of vehicle 34 for purposes of the present invention, attention is now directed to diagnostic work station 32. This work station includes its own external computer arrangement 36 which, as will be discussed in more detail below, is specifically designed for three primary purposes. First, it is designed to control the operation of one or more specific actuators independent of one another and independent of the onboard ECM 10. Second, it is designed to simulate the operation of one or more specific sensors, independent of one another and independent of their actual operation. Third, computer arrangement 36 is designed to continuously monitor and analyze in real time all of the electronic data entering and exiting ECM 10 including actual data associated with the network of sensors and actuators.

Still referring to Figure 2, work station 32 also includes an arrangement 38 which also serves a number of purposes. First, it serves to selectively and temporarily disconnect one or more specific sensors and/or actuators from ECM 10. Second, and at the same time, arrangement 38 serves to connect external computer arrangement 36 to those actuators that have been temporarily disconnected from ECM 10 so that the external computer arrangement can override the ECM and control those actuators. Third, arrangement 38 serves to connect the external computer arrangement 36 into the circuitry of ECM 10 associated with those sensors that have been temporarily disconnected in order to simulate the operation of those sensors. Fourth, arrangement 38 serves to connect external computer arrangement 36 to ECM 10 for monitoring the data entering and/or leaving the ECM, that is, the data passing between the ECM and various vehicle drive system components. Thus, as computer arrangement 36 operates a given actuator, for example, actuator A6, and simulates one or more sensors, for example, sensors S3 and

S4, it can also monitor the other actuators and sensors, that is, those actuators and sensors that remain connected to the ECM.

Having described work station 32 generally, attention is now directed to a number of particular examples of the way in which it may be used to diagnose problems associated with the vehicle 34. As one such example, it may be necessary to observe how the advance-retard angle associated with the vehicle's ignition timing changes with temperature. In this case, all of the drive system components in the vehicle remain connected to onboard ECM 10, except for a particular temperature sensor, for example sensor S4. This latter sensor is disconnected from its associated circuitry in ECM 10 and the associated circuitry is connected by arrangement 38 to external computer arrangement 36 through a cooperating computer-side terminal 22 via terminal T4, as will be seen. In this way, computer arrangement 36 can be operated to simulate the temperature sensor connected to T4 by generating the appropriate signal to ECM 10. By modulating this signal in the same way as the actual sensor S4 would, the ECM can be made to believe that the engine itself is varying in temperature causing it to vary the ignition timing accordingly. As a result, the vehicle's advance-retard angle can be observed as a function of temperature without ever leaving the service garage.

As another example, it may be necessary to test the performance of the vehicle's air management system. This system is supposed to allow a certain amount of air to flow from the exhaust back into the intake manifold for controlling the temperature in the manifold by using the heat from the exhaust air. This is controlled by a certain actuator, for example, the exhaust recirculation valve in General Motors cars. However, this valve will only open

under certain conditions. One such condition is when the vehicle is under load, as briefly mentioned earlier in the discussion of Figure 1. Thus, if the vehicle is at the garage, the vehicle's ECM will not itself open the exhaust recirculation valve since the vehicle itself is not under load. At the same time, it is not practical to actually drive the vehicle. Under these circumstances, work station 32 is especially appropriate. In this case, computer arrangement 36 takes over control of certain actuators and simulates certain sensors to make ECM 10 think that the vehicle is under a load. At the same time, it continuously monitors the valve in question in order to see if it actually does open the proper way under this load. Alternatively, it is also possible to use computer arrangement 36 to directly control the EGR value, by disconnecting it from ECM 10, and driving it to open, simultaneously monitoring other vehicle conditions such as temperature and fuel modulation in order to discern whether the value is operating properly.

The foregoing have been two examples of the way in which work station 32 is capable of taking an interactive role in diagnosing vehicle 34. The present invention is certainly not limited to those particular examples. In fact, in certain cases, work station 32 may be used solely for monitoring and analyzing certain vehicle functions without any interactive role at all. An example of this might be the vehicle's cruise control. Since the cruise control is not critical to the vehicle's operation, it may be desirable, from an economic standpoint, to provide the work station without means for interacting with the cruise control. In this case, the cruise control would be connected to computer arrangement 36 in a "monitor only" mode, in which case, the computer arrangement can still analyze operation of the cruise control and not directly affect its operation. In

a most economical version of work station 32, it would be designed only to continuously monitor and analyze in real time electronic data entering and exiting the ECM without any interactive roles at all. In this embodiment, the work station serves as a highly sophisticated analytical tool far superior to the breakout box illustrated in Figure 1, but would have less diagnostic capability than the interactive work station illustrated in Figure 2.

Having described the way in which work station 32 functions generally and having recited particular examples, attention is now directed to a more detailed discussion of computer arrangement 36 and connector arrangement 38. As illustrated in Figure 2, this latter arrangement including what may be referred to as a pod 40 which is comprised of a series of lines or channels C1, C2 and so on, include electronic switching circuits to be described below. This pod is disengageably connectable to a vehicle adaptor 42 by means of their respective plug-in cable harnesses 44 and 46. Adaptor 42 is comprised of its own auto-side connector 48 and its own computer-side connector 50, each of which includes its own plug-in terminals complementary to plug-in terminals 18 and 22. In this way the connectors 16 and 48 and the connectors 20 and 50 can be respectively connected together. The reason that the adaptor 42 is disengageably connectable with pod 40 by means of plug-in harnesses 44 and 46 is that the connectors 16 and 20 may differ for different vehicle makes and models and, hence, different adapters must be used. For example, in one vehicle make, the terminal T1 associated with the sensor S1, as shown in Figure 2, is connected to Channel C1. However, while not shown, for a different vehicle make, the terminal T1 may be associated with different drive system component, for example, sensor S4, and might therefore be connected through the cooperating adaptor to Channel C^4 for example. Thus,

each adapter has its own unique way of connecting terminals T1, T2 and so on with channel lines C1, C2 and so on.

As stated above, pod 40 is comprised of a series of electronic switching circuits which may be readily provided by those with ordinary skill in the art. However, for purposes of simplicity, these switching circuits are depicted in Figure 2 as simple mechanical switches and will be referred to herein as either switches or switching circuits. It is important to note that there are three different sets of switching circuits which perform three different functions. There is a first set of switching circuits generally represented by the switches S1, S2, S3 and so on. A second set is indicated at S'1, S'2 and so on, while a third set is shown at S"5, S"6, S"8 and S"10. The function of each set will be described below.

Switches S1, S2, S3 and so on function to selectively connect or disconnect corresponding auto-side terminals 18 to or from associated computer-side terminals 22. Thus, the switch S1 on channel line C1 is shown in its closed condition, thereby connecting the T1 terminal 18 to the T1 terminal 22. This in turn will electrically connect the sensor S1 to its associated circuitry in ECM 10 through the plug-in terminals T1. This is also true for switch S2 on channel line C2 which maintains sensor S2 connected to ECM 10. On the other hand, sensors S3 and S4 are shown in an opened condition, thereby disconnecting the T3 and T4 terminals 18 from the T3 and T4 terminals 22 which, in turn, disconnect sensors S3 and S4 from ECM 10. Note that switches S6 is open, switches S5 and S10 are closed, and there are no switches S associated with channel lines C7, C8 and C9. The C7 channel line, which is a monitor only line as described above, may be connected to, for example, the connector terminals associated with the vehicle's cruise

control. In this way, computer arrangement 36 can monitor and analyze the cruise control but it cannot interact with it. The C9 line in Figure 2 is actually provided to symbolically represent a series of lines for monitoring all of the other lines. This is more realistically depicted in Figure 3, as will be seen. The C8 line will be discussed hereinafter.

The second series of switches, S'1, S'2 and so on, serve to connect corresponding computer-side terminals 22 to the sensor simulating circuitry 56 within computer arrangement 36 while the third series of switches S"5, S"6 and S"8 serve to connect the corresponding auto-side terminals 18 to the actuator driving circuit 56 within computer arrangement 36. Thus, for example, switch S'1 is shown opened and therefore assures that the circuitry within the ECM 10 and connected to the T1 computer-side terminal 22 is not driven by external computer arrangement 36. On the other hand, switching circuit S'3 connects computer arrangement 36 to the circuitry in ECM 10 associated with sensor S3 through the T3 computer-side terminal 22. At the same time, switching circuit S"6 is closed and therefore connects actuator A6 with computer arrangement 36 through the T6 terminal 18.

With the possible exception of channel line C8, the status of the other switching circuits should be self explanatory from Figure 2 and the discussion immediately above. Note specifically that the switching circuits S' are associated with sensors and thus connect the computer arrangement 36 to ECM 10 while the switching circuits S" are associated with actuators and hence connect computer arrangement 36 to the actuators. With particular regard to line C^8, it should be noted that it includes both an S' and an S" switching circuit. This is because the C^8 line serves to test the ground lines in the entire vehicle system.

By closing the switch S'8, the ground lines in the ECM 10 can be resistance tested by injecting a known current into the line and measuring the resultant voltage. This is also true for the ground lines of the vehicle drive system side by closing the switch S"8. While only one such line C8 is shown, there are usually a number of such lines.

Still referring to Figure 2, attention is now directed to a more detailed discussion of computer arrangement 36. As seen there, this arrangement includes its own CPU 52 which can be, for example, part of a readily providable personal computer including an associated monitor 54 and keyboard 55. The arrangement also provides a suitable and readily providable interface between the computer including the necessary digital/analog converters one of which is generally indicated at 56 and analog/digital converters generally indicated at 58. Note that the digital/analog converters 56 allow CPU 52 to drive (actually control the operation of) particular vehicle actuators through switching circuits S" and simulate particular sensors feeding into circuitry within the ECM 10 through cooperating switching circuits S'. On the other hand, the analog/digital converters allow the external CPU 52 to "listen to", that is, monitor data entering and leaving ECM 10. In the case of this listening function, one or more A/D converters can be used for listening to all the terminal lines utilizing a suitable and readily providable sweep mechanism which is operated in a time slicing mode. Also, as will be seen hereinafter in conjunction with Figure 3, some of the D/A converters associated with actuators are actually driver circuits including on-off switches. Further, note that channels C1 - C10 in pod 40 connect to A/D circuitry 58 through a conventional and readily providable multiplexer 59 forming part of the sweep mechanism just mentioned so that individual

terminal lines and specific groups of terminal lines can be scanned by the CPU.

As indicated above, CPU 52 may be part of any suitable and readily providable computer, for example a standard personal computer. The software used to run the computer, represented generally by the diagrammatically depicted look up table 59 or menu, is also readily providable by those with ordinary skill in the art in view of the teachings herein. The software must be designed to control the various actuators in the intended manner and simulate the various sensors. It also must have the ability to analyze the various data presented to the external computer. A particular feature of work station 32 resides in a specific software database maintained within CPU 52. As indicated above, different vehicle makes and/or models compatible with work station 32 may include different sensors or actuators, different onboard computers and/or a different arrangement of auto-side and computer-side terminals. As a result, external CPU 52 includes a database for distinguishing between any of these differences in different vehicle makes and models. Thus, the automotive service professional can easily enter the appropriate vehicle identification into CPU 52 using keyboard 55 and provide the appropriate adaptor 32 in order to make the work station compatible with the particular vehicle in question. To this end, the database also includes performance information pertaining to specific sensors and actuators for particular vehicle makes and models. In addition, the CPU and its software include suitable and readily providable means for storing electronic data presented to it into memory, a database having exemplary data associated with the networks of sensors and actuators, and means for comparing the actual data stored in memory with the exemplary data. The CPU and its software also include suitable and readily providable means for carrying

out different diagnostic tests by operating certain specific actuators and simulating certain specific sensors in a predetermined way.

Software menu 60 is shown specifically including an "AUTO SELECT" item which represents a data base for distinguishing between vehicle makes and models. The T1 - T10 items represent data associated with the sensors, actuators and other components connected with connector terminals T1 - T10. As stated above, this data varies with the particular vehicle selected and would include for certain components the desired performance criteria to be used as a reference against actual performance data. The items labeled "Test No. 1", "Test No. 2" and so on refer to a data base for carrying out different predetermined diagnostic tests. The menu 60 illustrated in Figure 2 is by no means complete, nor is it intended to be complete. It is provided rather as an example of the necessary software required to operate CPU 52 in the desired manner, which software is readily providable, as indicated above. A more detailed discussion of the way in which the overall work station operates from a software standpoint will follow.

Turning now to Figure 3, attention is directed to a more accurate representation of the switching circuits within pod 40. In this case, the terminal lines associated with terminals T1 and T2 are shown as monitoring lines and, hence, include no switching circuits at all. On the other hand, the terminal lines associated with terminals T3, T4 and T5 do include switching circuits. Note specifically that a single switching circuit is used to combine the function of the previously described switches S and S' or S". Thus, for example, in the case of terminal T3, a single switching circuit S"3 is used to connect the auto-side and ECM side terminals T3 to one another and alternatively to connect

the ECM side terminal T3 to D/A circuitry within computer arrangement 36. This is also the case for switching circuit S"4. On the other hand, the terminal line T5 includes a switching circuit Sw5 which in one position connects together the ECM side and auto-side terminals T5 and in the opposite position connects computer arrangement 36, actually its driver circuit 56, to the auto-side terminal T5 for connection with the associated actuator A5. As indicated previously, some if not all of the actuators are controlled through driver circuits including on/off switches rather than through D/A converters. In this way, it is insured that any given actuator is always driven by the external computer in a way which is consistent with the actuator's electrical properties, i.e., voltage, current, impedance, etc. For example, a solenoid requires different drive parameters than a stepper monitor. Note also that not only the monitoring lines T1 and T2 in Figure 3 are shown including A/D converters but all of the other lines, that is, those including switching circuits also include A/D converters which serve to monitor or listen to those lines, regardless of the position of any given switching circuit. In this latter regard, in actual practice, it may be desirable to include a single A/D converter for listening purposes along with a sweep mechanism operated in a time slice mode.

Having now described overall workstation 32, attention is now directed to a specific example of the way in which it operates from a software standpoint. This example is not intended to limit the present invention. The discussion to follow will be organized by means of headings in association with Figures 4-5, starting with a discussion of the Data Base Structure, and followed by examples of various predetremined tests which the system is capable of performing.

1. DATA BASE STRUCTURE (see Figure 4)

The data base (DB) is composed of various tables as shown in Figure 4, as follows:

Component Table: For every component used with any vehicle, there is an entry in this table. Every entry contains the component identification (ID), type (sensor, thermistor, solenoid, etc.) and electrical parameters (min-max volts, resistance, inductance, translation tables to physical units, etc.).

Channel Table: For every channel C1, C2 and so on in the pod there is an entry in this table. Every entry contains the channel mux-address, the switch address, the D/A address, and other electrical parameters (i.e. gain, impedence, drive capabilities, etc.).

2. CONNECTOR TABLE: For every ECM used in any vehicle, there is an entry in this table describing the vehicle connector 14 (see Figure 1). Every entry is itself a table with an entry for every terminal on the particular ECM. Every terminal entry contains the terminal name (e.g., T1, T2), the component connected to this terminal, and the channel C1, C2, and so on, through which this terminal is routed in pod 40.

Engine Table: For every engine used in any vehicle there is an entry in this table containing the vehicle ID number (VIN), general engine information (i.e., number of cylinders, ignition type, injection type, etc.) and the ID of the connector for this engine.

The following specific information should be noted for exemplary purposes.

1. Many engines may share the same connector.

2. Many connectors may have the same terminal configuration.

3. Different components may connect to same terminal on different connectors.

4. Some channels may connect to different components on different connectors.

3. TEST FLOW

Having described the contents of information in the DB, we now proceed with examples of how this information is used in conjunction with actual testing of a vehicle. The first example will be what is called a sweep test, invoked by say item Test No. 1 in menu 60 of Fig. 2. The sweep test is a software function that examines all terminals of a given vehicle sequentially, monitoring them under known conditions for abnormal behavior.

The second example to be discussed, is a functional bypass test, invoked say by item Test No. 5 of menu 60, Fig. 2. A functional test will look at a group of terminals simultaneously, examining a particular correlation in their operation.

4. SWEEP TEST INFORMATION FLOW

Sweep tests are divided into functional groups: key off, key on-engine off, cranking and engine running tests.

Key Off Tests: These tests look at all power ground lines. A software function scans the connector table for the vehicle (Fig. 4) searching for those terminals connected to a component of the type "POWER" or "GROUND", as contained in the component information pointed at through the connector table. For every power terminal, the voltage is read from

the appropriate channel and compared to the nominal values of the matching component in the DB.

For every ground terminal, voltage is read and compared as above, then the appropriate switch S" is turned on, routing that channel to one of the D/A's. The particular D/A is then driven by software to inject a known current into the line connected to the terminal on the car side. Voltage drop is read from the appropriate channel and line resistance is computed and compared to the DB values.

Key on-Engine Off : These tests look at all sensors and actuators. For every sensor, voltage is read from the appropriate channel and compared to DB values as above. For all solenoids (actuators) voltage and resistance are measured as for ground lines. In addition, when current is injected into a solenoid, the actual current taken by the solenoid is plotted against time, and inductance is computed from this curve, and compared to DB values.

5. BYPASS TEST INFORMATION FLOW

As an example, consider the oxygen sensor bypass test.

Background: Under constant running conditions (RPM and load) the vehicle ECM will constantly monitor the oxygen sensor output which may be high, indicating high oxygen contents in the exhaust manifold, or low, indicating low oxygen. The ECM responds by modulating the fuel injectors to counter the oxygen readings. Thus, when oxygen is high, the ECM will widen the injector pulse width, causing more fuel to be delivered into the combustion chamber, eventually reducing the oxygen contents in the exhaust manifold, and vice versa when oxygen is low. This scheme is called a negative feedback loop, where injector pulse width is the controlled variable and oxygen is the error signal.

Test Description: While the engine is running, the system 32 will inject a simulated oxygen signal into the ECM. The signal is a square wave, with min-max voltage range based on DB values for a given oxygen sensor. While injecting this signal, the system will simultaneously monitor the Injector driver line, computing in real time the variation in injector pulse width, and also the output of the real oxygen sensor.

Expected Result: The correlation between the injected signal and fuel modulation indicates whether or not the ECM is properly responding to variations in oxygen. The skew between the injected oxygen and the real oxygen indicates the time response of the oxygen sensor. For a vehicle without any faults, the schematic results are shown in Figure 5.

6. TEST FLOW FOR OXYGEN BYPASS

A software function is provided within the system to execute the above test. First, the connector table for the vehicle (Figure 4) is scanned, searching for the terminals corresponding to the oxygen signal, the injector drivers (one or more) and the tach signal (RPM). The oxygen channel switch is configured for bypass into the ECM. The appropriate D/A is configured to generate a square wave with min-max voltage equal to nominal values for oxygen from the DB. The injector driver, the oxygen sensor and the tach signal are configured for "Read" (to listen) by properly selecting their respective channels in the A/D mux. The user is instructed to rev the engine to 2000 RPM, and the test begins:

The system monitors the tach signal, waiting for 2000 RPM. At that point, the D/A is enabled which causes the

simulated signal to be generated. The program then monitors simultaneously the simulated value, the real oxygen value and the injector driver. The injector signal is converted in real time to a pulse-width value, and is plotted against time together with the other values. This goes on for approximately 15 seconds, at which time bypass is disabled and monitoring stops. The final stage is a mathematical computation done on the data recorded in memory. The correlation of simulated oxygen and injector pulse width is computed, and the skew between simulated oxygen and real oxygen is measured. Both values are compared against good known results.

It is to be understood that the present invention is not limited to the particular computer arrangement 36 or the particular connector arrangement 38 illustrated in Figures 2 and 3. Rather, based on the teachings herein, one with ordinary skill in the art can readily modify either of these arrangements so long as they fulfill the functions herein. Moreover, based on the teachings herein, and with suitable and readily providable knowledge about particular automotive vehicles, one with ordinary skill in the software art can readily design the software used to operate computer 52. The present invention does not relate to the software per se but rather to the way in which the overall diagnostic station is able to continuously monitor and analyze vehicle 34 and more particularly to the way it is able to take an interactive role in the diagnostic process. In an actual working embodiment, an IBM PC AT or compatible system has been provided. Tables 1-3 forming the Appendix I (pages A1-A20) attached hereto list examples of actual engines, specific functions and tests by the actual embodiment. The present invention contemplates but is not limited to these particular engines, functions and tests.

APPENDIX

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/*********************************************************/
/*   TABLE - 1 : ENGINES CURRENTLY SUPPORTED             */
/*********************************************************/

LEGEND :

 5  MAKE :
     GM          - GENERAL MOTORS (ALL DIVISIONS)
     FORD        - FORD MOTOR CO.  (ALL DIVISIONS)
     CHR         - CHRYSLER (ALL DIVISIONS)
     TOYO        - TOYOTA (ALL DIVISIONS)

10   VIN : THE FEDERALLY MANDATED 17 DIGIT VEHICLE IDENTIFICATION NUMBER,
           FOUND BEHIND THE WINDSHIELD OF EVERY VEHICLE SOLD IN THE USA.  THE
           FIRST DIGIT IS COUNTRY CODE, THE SECOND IS MANUFACTURER CODE, THE
           EIGTH DIGIT IS ENGINE ID AND THE TENTH DIGIT IS YEAR CODE.

     CYLINDERS :
15    L4 - 4 CYLINDERS, LINEAR CONFIGURATION
      V6 - 6 CYLINDERS, "V" CONFIGURATION
      V8 - 8 CYLINDERS, "V" CONFIGURATION

     DISPLACEMENT : IN LITERS.

     FUEL-SYSTEM :
20    CARB              - CARBURATOR
      EFI               - ELECTRONIC FUEL INJECTION
      TBI               - THROTTLE BODY INJECTION
      TPI               - TUNES PORT INJECTION
      CFI               - CONTINUOUS FUEL INJECTION
25    MPI / MPFI        - MULTI PORT INJECTION
      SFI / SEFI / SPFI - SEQUENTIAL FUEL INJECTION
```

	MAKE	YEAR	ENGINE -ID	CYLINDERS	DISPLACEMENT	FUEL -SYS	COMMENTS
	GM	1981	3	V6	3.8L	CARB	TURBO
	GM	1981	4	V6	4.1L	CARB	
5	GM	1981	5	L4	2.5L	CARB	
	GM	1981	6	V8	5.7L	CARB	
	GM	1981	9	L4	1.6L	CARB	
	GM	1981	A	V6	3.8L	CARB	
	GM	1981	B	V8	5.7L	CARB	
10	GM	1981	F	V8	4.3L	CARB	
	GM	1981	H	V8	5.0L	CARB	
	GM	1981	J	V8	4.4L	CARB	
	GM	1981	K	V6	3.8L	CARB	
	GM	1981	L	V8	5.7L	CARB	
15	GM	1981	S	V8	4.3L	CARB	
	GM	1981	T	V8	4.9L	CARB	TURBO
	GM	1981	W	V8	4.9L	CARB	
	GM	1981	X	V6	2.8L	CARB	
	GM	1981	Y	V8	5.0L	CARB	
20	GM	1981	Z	V6	2.8L	CARB	
	GM	1982	0	L4	1.8L	TBI	
	GM	1982	1	V6	2.8L	CARB	
	GM	1982	2	L4	2.5L	TBI	
	GM	1982	3	V6	3.8L	CARB	TURBO
25	GM	1982	4	V6	4.1L	CARB	
	GM	1982	5	L4	2.5L	CARB	
	GM	1982	7	V8	5.0L	CFI	
	GM	1982	8	V8	5.7L	CFI	
	GM	1982	8	V8	4.3L	CARB	
30	GM	1982	A	V6	3.8L	CARB	
	GM	1982	B	V6	2.8L	CARB	TRUCK
	GM	1982	B	L4	2.0L	CARB	
	GM	1982	C	L4	1.6L	CARB	CAL & FED 5 SPEED
	GM	1982	C	L4	1.6L	CARB	FED AUTO 4 SPEED
35	GM	1982	E	V6	3.0L	CARB	
	GM	1982	F	L4	2.5L	CARB	
	GM	1982	G	L4	1.8L	CARB	
	GM	1982	H	V8	5.0L	CARB	
	GM	1982	J	V8	4.4L	CARB	
40	GM	1982	K	V6	3.8L	CARB	
	GM	1982	L	V8	5.7L	CARB	
	GM	1982	R	L4	2.5L	TBI	
	GM	1982	X	V6	2.8L	CARB	
	GM	1982	Y	V8	5.0L	CARB	
45	GM	1982	Z	V6	2.8L	CARB	

MAKE	YEAR	ENGINE -ID	CYLINDERS	DISPLACEMENT	FUEL -SYS	COMMENTS
GM	1983	0	L4	1.8L	TBI	
GM	1983	1	V6	2.8L	CARB	
GM	1983	2	L4	2.5L	TBI	
GM	1983	4	V6	4.1L	CARB	
GM	1983	5	L4	2.5L	CARB	
GM	1983	6	V8	5.7L	CARB	
GM	1983	8	V8	5.7L	CFI	
GM	1983	8	V6	3.8L	CARB	TURBO
GM	1983	9	V6	3.8L	CARB	
GM	1983	9	V8	5.0L	CARB	
GM	1983	A	V6	3.8L	CARB	
GM	1983	B	V6	2.8L	CARB	TRUCK
GM	1983	B	L4	2.0L	CARB	
GM	1983	C	L4	1.6L	CARB	FEDERAL
GM	1983	E	V6	3.0L	CARB	
GM	1983	F	L4	2.5L	CARB	
GM	1983	H	V8	5.0L	CARB	
GM	1983	L	V6	2.8L	CARB	
GM	1983	P	L4	2.0L	TBI	
GM	1983	R	L4	2.5L	TBI	
GM	1983	S	V8	5.0L	CFI	
GM	1983	X	V6	2.8L	CARB	
GM	1983	Y	V8	5.0L	CARB	
GM	1983	Z	V6	2.8L	CARB	
GM	1984	0	L4	1.8L	TBI	
GM	1984	1	V6	2.8L	CARB	
GM	1984	2	L4	2.5L	TBI	
GM	1984	3	V6	3.8L	MPI	
GM	1984	4	V6	4.1L	CARB	
GM	1984	6	V8	5.7L	CARB	
GM	1984	8	V8	5.7L	CFI	
GM	1984	9	V6	3.8L	SFI	TURBO
GM	1984	9	V8	5.0L	CARB	
GM	1984	9	V6	3.8L	CARB	
GM	1984	A	V6	3.8L	CARB	
GM	1984	B	V6	2.8L	CARB	TRUCK
GM	1984	C	L4	1.6L	CARB	FEDERAL
GM	1984	D	V6	4.1L	CARB	TRUCK
GM	1984	E	V6	3.0L	CARB	
GM	1984	F	V8	5.0L	CARB	TRUCK
GM	1984	G	V8	5.0L	CARB	
GM	1984	H	V8	5.0L	CARB	
GM	1984	J	L4	1.8L	MPI	TURBO
GM	1984	L	V8	5.7L	CARB	TRUCK
GM	1984	L	V6	2.8L	CARB	
GM	1984	P	L4	2.0L	TBI	
GM	1984	R	L4	2.5L	TBI	
GM	1984	X	V6	2.8L	CARB	
GM	1984	Y	V8	5.0L	CARB	
GM	1984	Z	V6	2.8L	CARB	

MAKE	YEAR	ENGINE -ID	CYLINDERS	DISPLACEMENT	FUEL -SYS	COMMENTS
GM	1985	0	L4	1.8L	TBI	
GM	1985	2	L4	2.5L	TBI	
GM	1985	3	V6	3.8L	MPI	
GM	1985	4	L4	1.6L	CARB	
GM	1985	6	V8	5.7L	CARB	
GM	1985	8	V8	4.1L	DFI	
GM	1985	8	V8	5.7L	TPI	
GM	1985	9	V8	5.0L	CARB	
GM	1985	9	V6	2.8L	MPI	
GM	1985	9	V6	3.8L	SFI	TURBO
GM	1985	A	V6	3.8L	CARB	
GM	1985	B	V6	2.8L	CARB	TRUCK
GM	1985	C	L4	1.6L	CARB	
GM	1985	C	L4	1.6L	CARB	
GM	1985	E	L4	2.5L	TBI	TRUCK
GM	1985	E	V6	3.0L	CARB	
GM	1985	F	V8	5.0L	CARB	TRUCK
GM	1985	F	V8	5.0L	TPI	
GM	1985	G	V8	5.0L	CARB	
GM	1985	H	V8	5.0L	CARB	
GM	1985	J	L4	1.8L	MPI	
GM	1985	K	L4	1.5L	CARB	
GM	1985	L	V8	5.7L	CARB	TRUCK
GM	1985	L	V6	3.0L	MPI	
GM	1985	M	L3	1.0L	CARB	
GM	1985	N	V6	4.3L	CARB	TRUCK
GM	1985	P	L4	2.0L	TBI	
GM	1985	R	L4	2.5L	TBI	
GM	1985	S	V6	2.8L	MPI	
GM	1985	U	L4	2.5L	TBI	
GM	1985	W	V6	2.8L	MPI	
GM	1985	X	V6	2.8L	CARB	
GM	1985	Y	V8	5.0L	CARB	
GM	1985	Z	V6	4.3L	TBI	

MAKE	YEAR	ENGINE -ID	CYLINDERS	DISPLACEMENT	FUEL -SYS	COMMENTS
GM	1986	0	L4	1.8L	TBI	
GM	1986	2	L4	2.5L	TBI	
GM	1986	3	V6	3.8L	SFI	
GM	1986	6	V8	5.7L	CARB	
GM	1986	7	V6	3.8L	SFI	TURBO
GM	1986	8	V8	5.7L	TPI	
GM	1986	9	V8	5.0L	CARB	
GM	1986	9	V6	2.8L	MPI	
GM	1986	A	V6	3.8L	CARB	
GM	1986	B	V6	3.8L	SFI	
GM	1986	C	L4	1.6L	CARB	FEDERAL
GM	1986	E	L4	2.5L	TBI	TRUCK
GM	1986	F	V8	5.0L	CARB	TRUCK
GM	1986	F	V8	5.0L	TPI	
GM	1986	G	V8	5.0L	CARB	
GM	1986	H	V8	5.0L	CARB	
GM	1986	J	L4	1.8L	MPI	TURBO
GM	1986	L	V8	5.7L	CARB	TRUCK
GM	1986	L	V6	3.0L	MPI	
GM	1986	N	V6	4.3L	CARB	TRUCK
GM	1986	P	L4	2.0L	TBI	
GM	1986	R	V6	2.8L	TBI	TRUCK
GM	1986	R	L4	2.5L	TBI	
GM	1986	S	V6	2.8L	MPI	
GM	1986	U	L4	2.5L	TBI	
GM	1986	W	V6	2.8L	MPI	
GM	1986	Y	V8	5.0L	CARB	
GM	1986	Z	V6	4.3L	TBI	TRUCK
GM	1986	Z	V6	4.3L	TBI	

MAKE	YEAR	ENGINE -ID	CYLINDERS	DISPLACEMENT	FUEL -SYS	COMMENTS
GM	1987	1	L4	2.0L	TBI	
GM	1987	3	V6	3.8L	SFI	
GM	1987	6	V8	5.7L	CARB	
GM	1987	7	V6	3.8L	SFI	TURBO
GM	1987	8	V8	5.0L	TPI	
GM	1987	8	V8	5.7L	TPI	
GM	1987	9	V6	2.8L	MPI	
GM	1987	9	V8	5.0L	CARB	
GM	1987	A	V6	3.8L	CARB	
GM	1987	C	L4	1.6L	CARB	
GM	1987	E	L4	2.5L	TBI	TRUCK
GM	1987	F	V8	5.0L	TPI	
GM	1987	G	V8	5.0L	CARB	
GM	1987	H	V8	5.0L	TBI	TRUCK
GM	1987	H	V8	5.0L	CARB	
GM	1987	K	V8	5.7L	TBI	TRUCK
GM	1987	K	L4	2.0L	TBI	
GM	1987	M	L4	2.0L	MPI	TURBO
GM	1987	N	V8	7.4L	TBI	TRUCK
GM	1987	R	V6	2.8L	TBI	TRUCK
GM	1987	R	L4	2.5L	TBI	
GM	1987	S	V6	2.8L	MPI	
GM	1987	U	L4	2.5L	TBI	
GM	1987	W	V6	2.8L	MPI	
GM	1987	Y	V8	5.0L	CARB	
GM	1987	Z	V6	4.3L	TBI	TRUCK
GM	1987	Z	V6	4.3L	TBI	

MAKE	YEAR	ENGINE -ID	CYLINDERS	DISPLACEMENT	FUEL -SYS	COMMENTS
GM	1988	1	L4	2.0L	TBI	
GM	1988	3	V6	3.8L	SFI	
GM	1988	6	V8	5.7L	CARB	
GM	1988	7	V6	3.8L	SFI	TURBO BUICK REGAL
GM	1988	8	V8	5.7L	TPI	
GM	1988	9	V6	2.8L	MPI	
GM	1988	C	V6	3.8L	SFI	
GM	1988	D	L4	2.3L	MPI	
GM	1988	E	V4	2.5L	TBI	TRUCK
GM	1988	E	V8	5.0L	TBI	
GM	1988	F	V8	5.0L	TPI	
GM	1988	G	V8	5.0L	CARB	
GM	1988	H	V8	5.0L	TBI	TRUCK
GM	1988	H	V8	5.0L	CARB	
GM	1988	K	V8	5.7L	TBI	TRUCK
GM	1988	K	L4	2.0L	TBI	
GM	1988	L	V6	3.0L	MPI	
GM	1988	M	L4	2.0L	MPI	TURBO
GM	1988	N	V8	7.4L	TBI	TRUCK
GM	1988	R	V6	2.8L	TBI	TRUCK
GM	1988	R	L4	2.5L	TBI	
GM	1988	S	V6	2.8L	MPI	
GM	1988	U	L4	2.5L	TBI	
GM	1988	W	V6	2.8L	MPI	4TH DIGIT W
GM	1988	W	V6	2.8L	MPI	ALL OTHERS
GM	1988	Y	V8	5.0L	CARB	
GM	1988	Z	V6	4.3L	TBI	TRUCK
GM	1988	Z	V6	4.3L	TBI	

MAKE	YEAR	ENGINE -ID	CYLINDERS	DISPLACEMENT	FUEL -SYS	COMMENTS
GM	1989	1	L4	2.0L	TBI	
GM	1989	7	V6	3.8L	SFI	TURBO
GM	1989	7	V8	5.7L	TBI	
GM	1989	8	V8	5.7L	TPI	
GM	1989	A	L4	2.3L	MPI	
GM	1989	C	V6	3.8L	SFI	
GM	1989	D	L4	2.3L	MPI	
GM	1989	E	L4	2.5L	TBI	TRUCK
GM	1989	E	V8	5.0L	TBI	
GM	1989	F	V8	5.0L	TPI	
GM	1989	H	V8	5.0L	TBI	TRUCK
GM	1989	K	V8	5.7L	TBI	TRUCK
GM	1989	K	L4	2.0L	TBI	
GM	1989	M	L4	2.0L	MPI	TURBO
GM	1989	N	V8	7.4L	TBI	TRUCK
GM	1989	N	V6	3.3L	MPI	
GM	1989	R	V6	2.8L	TBI	TRUCK
GM	1989	R	L4	2.5L	TBI	
GM	1989	S	V6	2.8L	MPI	
GM	1989	T	V6	3.1L	MPI	4TH DIGIT W
GM	1989	T	V6	3.1L	MPI	PONTIAC 6000
GM	1989	U	L4	2.5L	TBI	
GM	1989	W	V6	2.8L	MPI	4TH DIGIT W
GM	1989	W	V6	2.8L	MPI	ALL OTHERS
GM	1989	Y	V8	5.0L	CARB	
GM	1989	Z	V6	4.3L	TBI	TRUCK
GM	1989	Z	V6	4.3L	TBI	

MAKE	YEAR	ENGINE -ID	CYLINDERS	DISPLACEMENT	FUEL -SYS	COMMENTS
FORD	1981	A	L4	2.3L	CARB	MCU
FORD	1981	D	V8	4.2L	CARB	MCU
FORD	1981	E	V6	4.9L	CARB	MCU
FORD	1981	F	V8	5.0L	CFI	EEC III
FORD	1981	F	V8	5.0L	CARB	MCU
FORD	1981	G	V8	5.8L	CARB	EEC III
FORD	1981	G	V8	5.8L	CARB	MCU
FORD	1981	W	V8	5.8L	CARB	MCU
FORD	1982	3	V6	3.8L	CARB	MCU
FORD	1982	A	L4	2.3L	CARB	MCU
FORD	1982	D	V8	4.2L	CARB	MCU
FORD	1982	E	V6	4.9L	CARB	MCU
FORD	1982	F	V8	5.0L	CARB	MCU
FORD	1982	F	V8	5.0L	CFI	EEC III
FORD	1982	G	V8	5.8L	CARB	MCU
FORD	1982	G	V8	5.8L	CARB	EEC III
FORD	1982	W	V8	5.8L	CARB	EEC III
FORD	1983	3	V6	3.8L	CARB	MCU
FORD	1983	5	L4	1.6L	EFI	EEC IV
FORD	1983	A	L4	2.3L	CARB	MCU
FORD	1983	F	V8	5.0L	CFI	EEC III
FORD	1983	G	V8	5.8L	CARB	MCU
FORD	1983	G	V8	5.8L	CARB	EEC III
FORD	1983	W	L4	2.3L	EFI	TURBO EEC IV
FORD	1983	Y	V6	4.9L	CARB	MCU
FORD	1984	3	V6	3.8L	CFI	EEC IV
FORD	1984	5	L4	1.6L	EFI	EEC IV
FORD	1984	A	L4	2.3L	CARB	EEC IV
FORD	1984	F	V8	5.0L	CFI	EEC III
FORD	1984	J	L4	2.3L	CARB	EEC IV
FORD	1984	M	V8	5.0L	CFI	EEC IV
FORD	1984	R	L4	2.3L	CARB	EEC IV
FORD	1984	S	L4	2.3L	EFI	
FORD	1984	T	L4	2.3L	EFI	TURBO EEC IV
FORD	1984	W	L4	2.3L	EFI	TURBO EEC IV
FORD	1984	Y	V6	4.9L	CARB	EEC IV

	MAKE	YEAR	ENGINE -ID	CYLINDERS	DISPLACEMENT	FUEL -SYS	COMMENTS
	FORD	1985	3	V6	3.8L	CFI	
	FORD	1985	5	L4	1.6L	EFI	
5	FORD	1985	8	L4	1.6L	EFI	TURBO
	FORD	1985	A	L4	2.3L	CARB	TRUCK
	FORD	1985	A	L4	2.3L	CARB	
	FORD	1985	F	V8	5.0L	CFI	
	FORD	1985	G	V8	5.8L	CARB	MCU
10	FORD	1985	N	V8	5.0L	EFI	
	FORD	1985	S	V6	2.8L	CARB	
	FORD	1985	S	L4	2.3L	EFI	
	FORD	1985	T	L4	2.3L	EFI	TURBO
	FORD	1985	W	L4	2.3L	EFI	TURBO
15	FORD	1985	X	L4	2.3L	CFI	
	FORD	1985	Y	V6	4.9L	CARB	
	FORD	1986	3	V6	3.8L	CFI	
	FORD	1986	A	L4	2.3L	EFI	
	FORD	1986	A	L4	2.3L	CARB	
20	FORD	1986	D	L4	2.5L	CFI	
	FORD	1986	F	V8	5.0L	SEFI	
	FORD	1986	G	V8	5.8L	CARB	MCU
	FORD	1986	J	L4	1.9L	EFI	
	FORD	1986	N	V8	5.0L	EFI	
25	FORD	1986	S	L4	2.8L	CARB	
	FORD	1986	T	V6	2.9L	EFI	
	FORD	1986	T	L4	2.3L	EFI	TURBO
	FORD	1986	U	V6	3.0L	EFI	TRUCK
	FORD	1986	U	V6	3.0L	EFI	
30	FORD	1986	W	L4	2.3L	EFI	TURBO
	FORD	1986	X	L4	2.3L	CFI	
	FORD	1986	Y	V6	4.9L	CARB	
	FORD	1987	4	V6	3.8L	CFI	
	FORD	1987	9	L4	1.9L	CFI	
35	FORD	1987	A	L4	2.3L	EFI	
	FORD	1987	D	L4	2.5L	CFI	
	FORD	1987	F	V8	5.0L	CFI	
	FORD	1987	G	V8	5.8L	CARB	MCU
	FORD	1987	J	L4	1.9L	EFI	
40	FORD	1987	M	V8	5.0L	SEFI	
	FORD	1987	N	V8	5.0L	EFI	
	FORD	1987	T	V6	2.9L	EFI	
	FORD	1987	U	V6	3.0L	EFI	TRUCK
	FORD	1987	U	V6	3.0L	EFI	
45	FORD	1987	W	L4	2.3L	EFI	TURBO
	FORD	1987	X	L4	2.3L	CFI	
	FORD	1987	Y	V6	4.9L	EFI	

	MAKE	YEAR	ENGINE -ID	CYLINDERS	DISPLACEMENT	FUEL -SYS	COMMENTS
	FORD	1988	4	V6	3.8L	EFI	LINCOLN
	FORD	1988	4	V6	3.8L	EFI	
5	FORD	1988	9	L4	1.9L	CFI	
	FORD	1988	A	L4	2.3L	EFI	
	FORD	1988	D	L4	2.5L	CFI	
	FORD	1988	E	V8	5.0L	SEFI	
	FORD	1988	F	V8	5.0L	SEFI	
10	FORD	1988	G	V8	7.5L	EFI	
	FORD	1988	G	V8	5.8L	CARB	MCU
	FORD	1988	H	V8	5.8L	EFI	
	FORD	1988	J	L4	1.9L	EFI	
	FORD	1988	N	V8	5.0L	EFI	
15	FORD	1988	T	V6	2.9L	EFI	
	FORD	1988	U	V6	3.0L	EFI	AEROSTAR
	FORD	1988	U	V6	3.0L	EFI	
	FORD	1988	W	L4	2.3L	EFI	TURBO
	FORD	1988	X	L4	2.3L	CFI	
20	FORD	1988	Y	V6	4.9L	EFI	
	FORD	1989	4	V6	3.8L	SEFI	CONTINENTAL
	FORD	1989	4	V6	3.8L	SEFI	RWD
	FORD	1989	4	V6	3.8L	SEFI	FWD
	FORD	1989	9	L4	1.9L	CFI	
25	FORD	1989	A	L4	2.3L	EFI	
	FORD	1989	A	L4	2.3L	EFI	OHC
	FORD	1989	C	V6	3.8L	SEFI	SUPERCHARGE
	FORD	1989	D	L4	2.5L	CFI	
	FORD	1989	E	V8	5.0L	SEFI	
30	FORD	1989	F	V8	5.0L	EFI	
	FORD	1989	G	V8	5.8L	CARB	
	FORD	1989	G	V8	7.5L	EFI	
	FORD	1989	H	V8	5.8L	EFI	
	FORD	1989	J	L4	1.9L	EFI	
35	FORD	1989	N	V8	5.0L	EFI	
	FORD	1989	T	V6	2.9L	EFI	
	FORD	1989	T	L4	2.3L	EFI	TURBO
	FORD	1989	U	V6	3.0L	EFI	AEROSTAR
	FORD	1989	U	V6	3.0L	EFI	
40	FORD	1989	X	L4	2.3L	EFI	
	FORD	1989	Y	V6	4.9L	EFI	
	FORD	1989	Y	V6	3.0L	SEFI	

MAKE	YEAR	ENGINE -ID	CYLINDERS	DISPLACEMENT	FUEL -SYS	COMMENTS
CHR	1984	D	L4	2.2L	TBI	
CHR	1984	E	L4	2.2L	EFI	TURBO
CHR	1985	D	L4	2.2L	TBI	
CHR	1985	E	L4	2.2L	EFI	TURBO
CHR	1985	K	L4	2.5L	TBI	
CHR	1986	D	L4	2.2L	TBI	
CHR	1986	E	L4	2.2L	EFI	TURBO
CHR	1986	K	L4	2.5L	TBI	
CHR	1987	3	V6	3.0L	MPFI	
CHR	1987	D	L4	2.2L	TBI	
CHR	1987	E	L4	2.2L	MPFI	TURBO I
CHR	1987	K	L4	2.5L	TBI	W/ SMEC CONNECTOR
CHR	1987	K	L4	2.5L	TBI	
CHR	1987	L	L4	2.2L	MPFI	TURBO II SHELBY
CHR	1988	3	V6	3.0L	MPFI	
CHR	1988	D	L4	2.2L	TBI	
CHR	1988	E	L4	2.2L	MPFI	TURBO TURBO I
CHR	1988	K	L4	2.5L	TBI	
CHR	1988	L	L4	2.2L	MPFI	TURBO II SHELBY
CHR	1988	M	V6	3.9L	TBI	
CHR	1988	T	V8	5.2L	TBI	
CHR	1989	3	V6	3.0L	MPFI	PASSENGER CARS
CHR	1989	3	V6	3.0L	MPFI	TRUCKS AND VANS
CHR	1989	5	V8	5.9L	TBI	
CHR	1989	A	L4	2.2L	MPFI	TURBO TURBO II
CHR	1989	D	L4	2.2L	SPFI	
CHR	1989	G	L4	2.5L	TBI	
CHR	1989	J	L4	2.5L	MPFI	TURBO TURBO II
CHR	1989	K	L4	2.5L	SPFI	
CHR	1989	X	V6	3.9L	TBI	
CHR	1989	Y	V8	5.2L	TBI	
CHR	1989	Z	V8	5.9L	TBI	

MAKE	YEAR	ENGINE -ID	CYLINDERS	DISPLACEMENT	FUEL -SYS	COMMENTS
TOYO	1983	M	V6	2.8L		
TOYO	1983	R	L4	2.4L		
TOYO	1983	S	L4	2.0L		
TOYO	1984	M	V6	2.8L		
TOYO	1984	R	L4	2.4L		
TOYO	1984	S	L4	2.0L		
TOYO	1985	A	L4	1.6L		RWD COROLLA ONLY
TOYO	1985	A	L4	1.6L		EXCEPT RWD COROLLA
TOYO	1985	M	V6	2.8L		
TOYO	1985	R	L4	2.4L		
TOYO	1985	S	L4	2.0L		
TOYO	1986	A	L4	1.6L		RWD COROLLA ONLY
TOYO	1986	A	L4	1.6L		EXCEPT RWD COROLLA
TOYO	1986	M	V6	3.0L		
TOYO	1986	M	V6	2.8L		
TOYO	1986	S	L4	2.0L		
TOYO	1986	S	L4	2.0L		
TOYO	1987	A	L4	1.6L		RWD COROLLA ONLY
TOYO	1987	A	L4	1.6L		EXCEPT RWD COROLLA
TOYO	1987	M	V6	2.8L		
TOYO	1987	S	L4	2.0L		
TOYO	1987	S	L4	2.0L		
TOYO	1988	A	L4	1.6L		
TOYO	1988	M	V6	2.8L		
TOYO	1988	S	L4	2.0L		3S-GTE
TOYO	1988	S	L4	2.0L		
TOYO	1988	S	L4	2.0L		
TOYO	1988	V	V6	2.5L		
TOYO	1989	A	L4	1.6L		
TOYO	1989	S	L4	2.0L		3S-GTE
TOYO	1989	S	L4	2.0L		
TOYO	1989	S	L4	2.0L		
TOYO	1989	V	V6	2.5L		

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/*****************************************************************/
/*   TABLE - 2 : LIST OF ALL SENSORS, ACTUATORS AND SIGNALS      */
/*               CURRENTLY IN THE DATABASE FOR GM AND FORD.      */
/*   NOTE : A PARTICULAR VEHICLE WILL ONLY USE A SUBSET OF THE   */
/*          COMPONENTS IN THIS LIST, TYPICALLY 20-40.            */
/*****************************************************************/


LEGEND :

MAKE : MANUFACTURER ID.
 GM   - GENERAL MOTORS (ALL DIVISIONS).
 FORD - FORD MOTOR CO. (ALL DIVISIONS).

NAME : A SHORTHAND NAME USED BY THE MANUFACTURER TO DESIGNATE THE
       PARTICULAR SIGNAL.

TYPE : THE COMPONENT TYPE CONNECTED TO THIS SIGNAL.
 RELAY       - MECHANICAL ON/OFF RELAY.
 SWITCH      - ELECTRICAL ON/OFF SWITCH.
 SOLENOID    - ELECTRICAL SOLENOID.
 STP_MOTOR   - STEPPER MOTOR.
 WARN_LT     - WARNING LIGHT.
 THERMISTOR  - HEAT VARIABLE RESISTOR.
 RESISTOR    - VARIABLE RESISTOR (POTENTIOMETER).
 TRANSDUCER  - SOLID STATE SENSOR.
 PIEZO       - PIEZO ELECTRIC TRANSDUCER
 FREQ_GEN    - FREQUENCY GENERATOR.
 HALL_SWITCH - HALL EFFECT SWITCH.
 POWER       - POWER LINE.
 GROUND      - GROUND LINE.

DIRECTION :
 INPUT  - TO ECM, GENERALLY A SENSOR.
 OUTPUT - FROM ECM, GENERALLY AN ACTUATOR.
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MAKE	NAME	TYPE	DIRECTION	DESCRIPTION
GM	AC ON	SWITCH	INPUT	AIR CONDITIONING STATUS
GM	AC CLTCH	RELAY	OUTPUT	AIR CONDITIONING CLUTCH CONTROL
GM	AC RELAY	RELAY	OUTPUT	AIR CONDITIONING CONSTANT RELAY
GM	AC CUT/O	RELAY	OUTPUT	AIR CONDITIONING CUTOUT CONTROL
GM	AC P/SW	SWITCH	INPUT	AIR CONDITIONING PRESSURE SWITCH
GM	AD SOL	SOLENOID	OUTPUT	AIR DIVERTER SOLENOID
GM	AC SOL	SOLENOID	OUTPUT	AIR CONTROL SOLENOID
GM	AIR/SOL	SOLENOID	OUTPUT	AIR SWITCHING SOLENOID
GM	ALT C/SW	SWITCH	INPUT	ALITITUDE COMP SWITCH
GM	ATS	THERMISTOR	INPUT	AIR TEMPERATURE SENSOR SIGNAL
GM	BARO	PIEZO	INPUT	BAROMETRIC PRESSURE SENSOR
GM	BRK SW	SWITCH	INPUT	BRAKE SWITCH
GM	BYPASS	SWITCH	OUTPUT	IGNITION MODULE BYPASS
GM	CAN PURG	SOLENOID	OUTPUT	CANISTER PURGE SOLENOID
GM	CHK ENG	WARN_LT	OUTPUT	CHECK ENGINE LIGHT
GM	CAM REF	FREQ_GEN	INPUT	CAM REFERENCE SIGNAL
GM	CS MOD	SWITCH	OUTPUT	COLD START MODIFIER
GM	C/F CTL	RELAY	OUTPUT	COOLANT FAN CONTROL
GM	CF REQ	SWITCH	OUTPUT	COOLENT FAN REQUEST
GM	COOL LT	WARN_LT	OUTPUT	COOLANT TEMPERATURE LIGHT
GM	CON BATT	POWER	INPUT	CONTINUOUS BATTERY
GM	CRNK SIG	HALL_SWITCH	INPUT	CRANK SIGNAL
GM	CRNK REF	FREQ_GEN	INPUT	CRANK REFERENCE PULSE IN
GM	CRNK GND	GROUND	INPUT	CRANK REFERENCE GROUND
GM	C\SW	SWITCH	INPUT	CRUISE CONTROL SWITCH GENERAL
GM	C\ENAB	RELAY	INPUT	CRUISE ENGAGE
GM	C\RES	SWITCH	INPUT	CRUISE RESUME
GM	C\SET	SWITCH	INPUT	CRUISE SET
GM	CTS	THERMISTOR	INPUT	COOLANT TEMPERATURE SENSOR
GM	CLS	THERMISTOR	INPUT	COOLANT LEVEL SENSOR
GM	CYL SEL	SWITCH	INPUT	CYLINDER SELECT W/GROUND
GM	4CYL M	SWITCH	INPUT	4 CYLINDER SELECT W/GROUND
GM	6CYL M	SWITCH	INPUT	6 CYLINDER SELECT W/GROUND
GM	8CYL M	SWITCH	INPUT	8 CYLINDER SELECT W/GROUND
GM	DIAG EN	SWITCH	INPUT	DIAGNOSTIC TEST TERMINAL
GM	DREF	FREQ_GEN	INPUT	DISTRIBUTOR REFERENCE PULSE
GM	DREF 2X	FREQ_GEN	INPUT	DISTRIBUTOR REFERENCE 2X SIGNAL
GM	DREF 18X	FREQ_GEN	INPUT	DISTRIBUTOR REFERENCE 18X SIGNAL
GM	P/N DRV	SWITCH	OUTPUT	PARK NEUTRAL DRIVE INDICATOR
GM	EAC SOL	SOLENOID	OUTPUT	AIR DIVERTER SOLENOID
GM	E CELL	SWITCH	OUTPUT	VEHICLE ELASPED CELL TIMER
GM	ECC CLU	RELAY	OUTPUT	ELECTRONIC CLIMATE CONTROL CLUTCH
GM	EFE	RELAY	OUTPUT	EARLY FUEL EVAPERATION
GM	EGR POS	RESISTOR	INPUT	EXHAUST GAS RECIRCULATION POSTION
GM	EGR SW	SWITCH	INPUT	EGR DIAGNOSTIC SWITCH
GM	EGR V\SW	SWITCH	OUTPUT	EGR VAC CONTROL SWITCH
GM	EGR PWM	SOLENOID	OUTPUT	EGR PULSE WIDTH MOD
GM	EGRC	SOLENOID	OUTPUT	EGR CONTROL SOLENOID
GM	EGRC WOT	SWITCH	INPUT	EGR WIDE OPEN THROTTLE
GM	EGR CUT	SWITCH	INPUT	EXHAUST GAS RECIRCULATION RELAY
GM	EN AIR	SOLENOID	OUTPUT	AIR CONTROL SOLENOID
GM	ESC	FREQ_GEN	INPUT	ELECTRONIC SPARK RETARD CONTROL
GM	EST	FREQ_GEN	OUTPUT	ELECTRONIC SPARK TIMING CONTROL
GM	FP RLY	RELAY	OUTPUT	FUEL PUMP RELAY
GM	M/C SOL	SOLENOID	OUTPUT	MIXTURE CONTROL SOLENOID

MAKE	NAME	TYPE	DIRECTION	DESCRIPTION
GM	FUEL SIG	POWER	INPUT	FUEL SIGNAL
GM	TRNS SW	SWITCH	INPUT	GEAR SWITCH
GM	CTS GND	GROUND	INPUT	GROUND COOLANT TEMPERATURE SIGNAL
GM	MAF GND	GROUND	OUTPUT	MASS AIR FLOW GROUND
GM	MAP GND	GROUND	OUTPUT	MAP SENSOR GROUND
GM	MAT GND	GROUND	OUTPUT	MANIFOLD AIR TEMPERATURE GROUND
GM	HI G\SW	SWITCH	OUTPUT	HIGH GEAR SWITCH INPUT
GM	HD/LV	SOLENOID	OUTPUT	HOOD LOUVER SOLENOID
GM	HOT LT	WARN_LT	OUTPUT	HOT LIGHT
GM	IAC	STP_MOTOR	OUTPUT	IDLE AIR CONTROL
GM	IGN GND	GROUND	INPUT	IGNITION GROUND
GM	ILC	SOLENOID	OUTPUT	IDLE LOAD COMPENSATOR
GM	INJ	SOLENOID	OUTPUT	INJECTOR DRIVER
GM	INJ GND	GROUND	INPUT	INJECTOR GROUND
GM	INJ SEL	SWITCH	OUTPUT	INJECTOR SELECT
GM	ISC	STP_MOTOR	OUTPUT	IDLE SPEED CONTROL
GM	ISC N/SW	SWITCH	INPUT	IDLE SPEED NOSE SWITCH
GM	KEY PWR	POWER	INPUT	KEY ON POWER
GM	KNK SEN	PIEZO	INPUT	KNOCK SENSOR
GM	IAC	STP_MOTOR	OUTPUT	IDLE AIR CONTROL
GM	MAF	RESISTOR	INPUT	MASS AIR FLOW SENSOR
GM	MAF	FREQ_GEN	INPUT	MASS AIR FLOW SENSOR
GM	MA B/OFF	RELAY	OUTPUT	MASS AIR FLOW BURN OFF
GM	MAP	PIEZO	INPUT	MANIFOLD ABSOLUT PRESSURE
GM	MAT	THERMISTOR	INPUT	MANIFOLD AIR TEMPERATURE
GM	OS ATS	THERMISTOR	INPUT	OUTSIDE AIR TEMPERATURE
GM	OD RQ/AT	SWITCH	INPUT	AUTO TRANSMITION OVERDRIVE REQUEST
GM	OD RQ/MT	SWITCH	INPUT	MANUAL TRANSMITION OVERDRIVE REQUEST
GM	02	BATT_GEN	INPUT	OXYGEN SENSOR
GM	02 GND	GROUND	INPUT	OXYGEN SENSOR GROUND
GM	P/N	SWITCH	INPUT	PARK NEUTRAL
GM	P/AIR	SOLENOID	OUTPUT	PULSE AIR CONTROL VALVE
GM	PWRGND	GROUND	INPUT	POWER GROUND
GM	PS/SW	SWITCH	INPUT	POWER STEERING SWITCH
GM	RV/SW	SWITCH	OUTPUT	REVERSE GEAR SWITCH
GM	RBV	SOLENOID	OUTPUT	REAR VAC BREAK
GM	2ND G	SWITCH	OUTPUT	SECOND GEAR
GM	SRV/ENG	WARN_LT	OUTPUT	CHECK ENG LAMP OUTPUT
GM	SER DTA	COM_LINK	OUTPUT	SERIAL DATA COMMUNICATION LINK
GM	SIG RTN	GROUND	OUTPUT	SIGNAL RETURN (SENSOR GROUND)
GM	SHFT LT	WARN LT	INPUT	SHIFT INDICATOR LIGHT
GM	TAC SIG	FREC_GEN	OUTPUT	TACH REFERENCE SIGNAL
GM	TCCS	RELAY	OUTPUT	TORQUE CONVERTER CLUTCH RELAY
GM	3RD G	SWITCH	OUTPUT	THIRD GEAR
GM	1ST G	SWITCH	OUTPUT	FIRST GEAR
GM	TH KCK	SOLENOID	OUTPUT	THROTTLE KICKER
GM	TPS	RESISTOR	INPUT	THROTTLE POSITION SENSOR
GM	TPS GND	GROUND	OUTPUT	THROTTLE POSITION SENSOR GROUND
GM	TPS/BU	SWITCH	INPUT	TRANSMISSION UNITS IN GENERAL
GM	TRANG	SWITCH	INPUT	TRANSMISSION UNITS IN GENERAL
GM	VATS	FREQ_GEN	INPUT	VEHICLE ANTI THEFT SYSTEM
GM	VAC	RESISTOR	INPUT	VACUUM SENSOR
GM	V/MON	POWER	INPUT	VOLTAGE MONITOR
GM	V/REG	POWER	INPUT	VOLTAGE REGULATOR
GM	VSS	FREQ_GEN	INPUT	VEHICLE SPEED SENSOR
GM	VSS GND	GROUND	OUTPUT	VEHICLE SPEED SENSOR GROUND
GM	VREF 8V	POWER	OUTPUT	8 VOLT REFERENCE
GM	WST/G	SOLENOID	OUTPUT	WASTEGATE CONTROL

	MAKE	NAME	TYPE	DIRECTION	DESCRIPTION
	FORD	ACC	RELAY	OUTPUT	AIR CONDITIONING CLUTCH CONTROL
	FORD	AC CUT	RELAY	OUTPUT	AIR CONDITIONING CUTOUT CONTROL
5	FORD	AC ON	SWITCH	INPUT	AIR CONDITIONING STATUS
	FORD	ACT	THERMISTOR	INPUT	AIR CHARGE TEMPERATURE SENSOR
	FORD	BARO	PIEZO	INPUT	BAROMETRIC PRESSURE SENSOR
	FORD	BARO	SWITCH	INPUT	BAROMETRIC PRESSURE SENSOR
	FORD	BOO	SWITCH	INPUT	BRAKE ON/OFF SWITCH
10	FORD	CNAP	SOLENOID	OUTPUT	CANISTER PURGE SOLENOID
	FORD	CFC	RELAY	OUTPUT	COOLANT FAN CONTROL
	FORD	CK ENG	WARN_LT	OUTPUT	CHECK ENGINE LIGHT
	FORD	CASE GND	GROUND	INPUT	ECA CASE GROUND
	FORD	CID	FREQ_GEN	INPUT	CYLINDER ID SIGNAL
15	FORD	CLU OVR	SWITCH	INPUT	CLUTCH CONVERTER OVERRIDE SWITCH
	FORD	CLU SW	SWITCH	INPUT	CLUTCH ON/OFF SWITCH
	FORD	KAM	POWER	INPUT	KEEP ALIVE MEMORY
	FORD	CP	HALL_SWITCH	INPUT	CRANKSHAFT POSITION SENSO
	FORD	CP GND	GROUND	OUTPUT	CRANKSHAFT POSITION SENSOR GROUND
20	FORD	CRNK_SIG	BATT_GEN	INPUT	BATTERY VOLTAGE CRANKING SIGNAL
	FORD	CRU SW	SWITCH	INPUT	CRUISE CONTROL SWITCH
	FORD	DA LNK	COM_LINK	OUTPUT	DIAGNOSTIC DATA LINK
	FORD	DPI	SWITCH	OUTPUT	DUAL PLUG INHIBITOR
	FORD	DT SW	SWITCH	INPUT	DUAL TEMPERATURE SWITCH
25	FORD	ECT	THERMISTOR	INPUT	ENGINE COOLANT TEMPERATURE SENSOR
	FORD	EDF	BATT_GEN	OUTPUT	ELECTRIC DRIVE FA
	FORD	EEC RLY	RELAY	INPUT	EEC POWER RELAY
	FORD	EGO	BATT_GEN	INPUT	EXHAUST GAS OXYGEN SENSOR
	FORD	EGO GND	GROUND	OUTPUT	OXYGEN SENSOR GROUND
30	FORD	EGOR	BATT_GEN	INPUT	OXYGEN SENSOR (RIGHT SIDE)
	FORD	EGOL	BATT_GEN	INPUT	OXYGEN SENSOR (LEFT SIDE)
	FORD	EGOR GND	GROUND	OUTPUT	OXYGEN SENSOR GROUND (RIGHT SIDE)
	FORD	EGOL GND	GROUND	OUTPUT	OXYGEN SENSOR GROUND (LEFT SIDE)
	FORD	EGR C/O	SOLENOID	OUTPUT	EGR CUT OUT SOLENOID
35	FORD	EGR PFB	TRANSDUCER	INPUT	EGR PRESSURE FEEDBACK
	FORD	EGRV	SOLENOID	OUTPUT	EGR VENT SOLENOID
	FORD	EGRC	SOLENOID	OUTPUT	EGR CONTROL SOLENOID
	FORD	EVR	SOLENOID	OUTPUT	EGR VAC REGULATOR SOLENOID
	FORD	EVP	RESISTOR	OUTPUT	EGR VALVE POSITION SENSOR
40	FORD	EHC	RESISTOR	OUTPUT	EXHAUST HEAT CONTROL
	FORD	FBC	STP_MOTOR	OUTPUT	FEEDBACK CARBURETOR ACTUATO
	FORD	FCS	SOLENOID	OUTPUT	FUEL CONTROL SOLENOID
	FORD	FP MON	RELAY	INPUT	FUEL PUMP VOLTAGE MONITOR
	FORD	FP RLY	RELAY	OUTPUT	FUEL PUMP RELAY
45	FORD	TGR SW	SWITCH	INPUT	TRANSMISSION GEAR SWITCH INDICATOR
	FORD	PWRGND	GROUND	INPUT	POWER GROUND TO ENGINE BLOCK
	FORD	HEGO	BATT_GEN	INPUT	HEATED OXYGEN SENSOR
	FORD	HEGOG	GROUND	INPUT	HEATED OXYGEN SENSOR GROUND
	FORD	HEGOL	BATT_GEN	INPUT	HEATED OXYGEN SENSOR (LEFT SIDE)
50	FORD	HEGOR	BATT_GEN	INPUT	HEATED OXYGEN SENSOR (RIGHT SIDE)
	FORD	HT WS	RELAY	OUTPUT	HEATED WINSHIELD RELAY
	FORD	IGN GND	GROUND	INPUT	IGNITION GROUND (TFI MODULE)
	FORD	IDM	COM_LINK	INPUT	IGNITION DIAGNOSTIC MONITOR
	FORD	IMS	SWITCH	OUTPUT	IGNITION MODULE SIGNAL
55	FORD	INJ	SOLENOID	OUTPUT	INJECTOR DRIVER
	FORD	IAS	SOLENOID	OUTPUT	INLET AIR SOLENIOD
	FORD	ISC	STP_MOTOR	OUTPUT	IDLE SPEED CONTROL
	FORD	AIR BP	SOLENOID	OUTPUT	AIR BYPASS SOLENOID (THROTTLE)

	MAKE	NAME	TYPE	DIRECTION	DESCRIPTION
	FORD	ITS	SWITCH	OUTPUT	IDLE TRACKING SWITCH
	FORD	VEH PWR	POWER	INPUT	VEHICLE POWER (KEY ON)
5	FORD	KNK SEN	PIEZO	INPUT	KNOCK SENSOR SIGNAL
	FORD	LTMP SW	SWITCH	INPUT	LOW TEMPERATURE SWITCH
	FORD	MAF	FREQ_GEN	INPUT	MASS AIR FLOW SENSOR
	FORD	MAF GND	GROUND	OUTPUT	MASS AIR FLOW SENSOR GROUND
	FORD	MAP	PIEZO	INPUT	MANIFOLD ABSOLUTE PRESSURE SENSOR
10	FORD	MTEMP	SWITCH	INPUT	MID TEMPERATURE SWITCH
	FORD	NS SW	SWITCH	OUTPUT	NEUTRAL START SWITCH
	FORD	OCT SW	SWITCH	INPUT	OCTANE SWITCH
	FORD	OD CNL	SWITCH	OUTPUT	OVERDRIVE CANCEL INDICATOR LIGHT
	FORD	PSPS	SWITCH	INPUT	POWER STEERING PRESSURE SWITCH
15	FORD	PIP	FREQ_GEN	INPUT	PROFILE IGNITION PICK-UP
	FORD	SHFT LT	WARN_LT	OUTPUT	SHIFT INDICATOR LIGHT
	FORD	SIG RTN	GROUND	OUTPUT	SIGNAL RETURN (SENSOR GROUND)
	FORD	SHFT 3&4	SOLENOID	OUTPUT	SHIFT SOLENOID 3&4
	FORD	ST TRIG	DONT_KNOW	INPUT	SELF TEST TRIGGER
20	FORD	SPOUT	FREQ_GEN	OUTPUT	SPARK OUTPUT SIGNAL TO TFI MODULE
	FORD	SPR SOL	SOLENOID	OUTPUT	SPARK RETARD SOLENOID
	FORD	SCVNT	SOLENOID	OUTPUT	SPEED CONTROL SOLENOID
	FORD	SPC GND	GROUND	OUTPUT	SPEED CONTROL GROUND
	FORD	SCCS	SWITCH	INPUT	SPEED CONTROL COMMAND SWITCH
25	FORD	SC VAC	SOLENOID	OUTPUT	SPEED CONTROL VACUUM SOLENOID
	FORD	SCVNT	SOLENOID	OUTPUT	SPEED CONTROL VENT SOLENOID
	FORD	SRVT	TRANSDUCER	INPUT	SPEED CONTROL SERVO TRANSDUCER
	FORD	STI	RESISTOR	INPUT	SELF TEST INPUT
	FORD	SCS	SOLENOID	OUTPUT	SUPERCHARGE BYPASS SOLENOID
30	FORD	TAB	SOLENOID	OUTPUT	THERMACTOR AIR BYPASS SOLENOID
	FORD	TCC	RELAY	OUTPUT	TORQUE CONVERTER CLUTCH
	FORD	TAC SIG	FREQ_GEN	INPUT	TACH SIGNAL
	FORD	TAD	SOLENOID	OUTPUT	THERMACTOR AIR DIVERTER SOLENOID
	FORD	TD RLY	RELAY	OUTPUT	THERMACTOR DUMP RELAY
35	FORD	THRD GW	SWITCH	OUTPUT	THIRD GEAR SWITCH
	FORD	TKS RLY	RELAY	OUTPUT	THROTTLE KICKER RELAY
	FORD	TKS	SOLENOID	OUTPUT	THROTTLE KICKER SOLENOID
	FORD	TO TMP	RESISTOR	INPUT	TRANSMISSION OIL TEMPERATURE SENSOR
	FORD	TPS	RESISTOR	INPUT	THROTTLE POSITION SENSOR
40	FORD	TRAN 3&2	SWITCH	INPUT	TRANSMISSION GEAR SWITCH 3&2
	FORD	TRAN 4&3	SWITCH	INPUT	TRANSMISSION GEAR SWITCH 4&3
	FORD	TRN/SOL	SOLENOID	INPUT	TRANSMISSION LOCKUP SOLENOID
	FORD	TRAN SW	SWITCH	INPUT	TRANSMISSION SWITCH
	FORD	TTMP SW	SWITCH	INPUT	TRANSMISSION TEMPERATURE SWITCH
45	FORD	TRN/SOL	SOLENOID	INPUT	TRANSMISSION THROTTLE SOLENOID
	FORD	VS LO	SWITCH	INPUT	VACUUM SWITCH LO
	FORD	VS HI	SWITCH	INPUT	VACUUM SWITCH HI
	FORD	VS MED	SWITCH	INPUT	VACUUM SWITCH MED
	FORD	VAF	RESISTOR	INPUT	VANE AIR FLOW SENSOR
50	FORD	VVC	BATT_GEN	INPUT	VARIABLE VOLTAGE CHOKE
	FORD	VAT	THERMISTOR	INPUT	VANE AIR TEMPERATURE SENSOR
	FORD	VEH PWR	POWER	INPUT	VEHICLE POWER
	FORD	VSS	FREQ_GEN	INPUT	VEHICLE SPEED SENSOR
	FORD	VSS GND	GROUND	OUTPUT	VEHICLE SPEED SENSOR GROUND
55	FORD	VREF5	POWER	OUTPUT	VOLTAGE REF (5 VOLT SENSOR INPUT)
	FORD	VREF9	POWER	OUTPUT	VOLTAGE REF (9 VOLT SENSOR INPUT)
	FORD	WG CTRL	SOLENOID	OUTPUT	WASTEGATE SOLENOID CONTROL
	FORD	WOT VAC	SWITCH	INPUT	WIDE OPEN THROTTLE VACUUM SWITCH

```
/*****************************************************************/
/*   TABLE - 3 :   TESTS PERFORMED DURING THE SWEEP TEST:        */
/*****************************************************************/
```

KEY OFF ENG OFF TESTS:

1) TEST VOLTAGE AT CONTINUOUS BATTERY PINS.
2) TEST RESISTANCE OF POWER GROUNDS.
3) TEST RESISTANCE OF THE IDLE AIR CONTROL STEPPER MOTOR.
4) TEST RESISTANCE OF THE IDLE SPEED CONTROL DC REVERSIBLE MOTOR.

KEY ON ENG OFF TEST:

1) TEST VOLTAGE AT KEY POWER PINS.
2) TEST VOLTAGE AT SYSTEM GROUND PINS.
3) TEST VOLTAGE AT SENSOR GROUND PINS.
4) TEST VOLTAGE AT VREF PINS.
5) TEST VOLTAGE OF TPS.
6) TEST VOLTAGE AIR TEMPERATURE SENSOR.
7) TEST VOLTAGE OF BARO SENSOR.
8) TEST VOLTAGE OF MANIFOLD AIR PRESSURE SENSOR.
9) TEST VOLTAGE OF MANIFOLD AIR FLOW SENSORE.
10) TEST VOLTAGE OF COOLANT TEMP SENSOR.
11) TEST VOLTAGE OF ALL SOLENOIDS.
12) TEST RESISTANCE OF ALL SOLENOIDS.
13) TEST VOLTAGE OF ALL INJECTORS.
14) TEST RESISTANCE OF ALL INJECTORS.

CRANKING TEST:

1) TEST RPM DURING CRANKING.
2) TEST FUEL PUMP OPERATION DURING CRANKING.
3) TEST MANIFOLD AIR PRESSURE DURING CRANKING.
4) TEST MANIFOLD AIR FLOW DURING CRANKING.
5) TEST CYLINDER ID SIGNAL DURING CRANKING.
6) TEST VOLTAGE DROP IN CONTINUOUS BATTERY PINS AFTER CRANKING.
6) TEST VOLTAGE DROP IN KEY POWER PINS AFTER CRANKING.

What is claimed is:

1. An interactive diagnostic system for an automotive vehicle of the type having (i) a network of sensors and actuators for independently sensing and actuating a number of different functions within the vehicle, (ii) an onboard computer for monitoring said sensors and controlling the operation of said actuators, and (iii) means for electrically connecting said onboard computer with said sensors and actuators, said connecting means including an auto-side connector having a series of auto-side plug-in terminals respectively connected with said sensors and actuators and a computer-side connector disengagably connectable to said auto-side connector and having corresponding, complementary computer-side plug-in terminals connected to appropriate circuitry within the computer, said diagnostic system comprising:

(a) first means for selectively and temporarily disconnecting one or more of said auto-side terminals from corresponding computer-side terminals, whereby to selectively and temporarily disconnect one or more specific sensors and/or actuators from said computer;

(b) second means temporarily connectable with said one or more specific auto-side terminals when the latter are disconnected from their corresponding computer-side terminals for controlling the operation of said one or more specific actuators independent of said onboard computer; and

(c) third means temporarily connectable with said one or more specific computer-side terminals when the latter are disconnected from their corresponding auto-side terminals for simulating the operation of said one or more specific sensors independent of the actual operation of these latter sensors.

2. A system according to Claim 1 wherein said first means includes a network of electronic switching circuits individually connected between individual auto-side and computer-side terminals, each of said switching circuits being designed to operate independent of the other circuits between a closed condition and an open condition for connecting and disconnecting its associated auto-side and computer-side terminals to and from one another.

3. A system according to Claim 1 wherein said second means includes an external computer arrangement separate from said onboard computer for controlling the operation of said one or more specific actuators independent of said onboard computer by generating specific information digitally, converting said digital information to analog signals and directing said analog signals to said one or more specific actuators through said one or more specific auto-side terminals.

4. A system according to Claim 3 wherein said third means includes said external computer arrangement separate from said onboard computer for simulating the operation of said one or more specific sensors independent of the actual operation of these latter sensors by generating specific signals digitally from said external computer, converting said digital signals to analog information and directing said analog information to the appropriate circuitry within said onboard computer through said one or more specific computer-side terminals.

5. A system according to Claim 4 wherein each of said second and third means includes a network of electronic switching circuits individually connected between said external computer arrangement and individual auto-side or computer-side terminals, each of said switching circuits

being designed to operate independently between a closed condition and an open condition for connecting and disconnecting the external computer arrangement to its associated auto-side or computer-side terminals.

6. A system according to Claim 5 wherein said first means includes a network of electronic switching circuits individually connected between individual auto-side and computer-side terminals, each of said switching circuits being designed to operate independently between a closed condition and an open condition for connecting and disconnecting its associated auto-side and computer-side terminals to and from one another.

7. A system according to Claim 6 wherein said computer arrangement includes means for operating said networks of electronic switching circuits individually or in any desired combination.

8. A system according to Claim 4 wherein different vehicle makes and/or models compatible with said system may include different sensors and/or actuators, a different onboard computer and/or a different arrangement of auto-side and computer-side terminals, and wherein said external computer arrangements includes a data base for distinguishing between any of said differences in different vehicle makes and models.

9. A system according to Claim 8 wherein said computer arrangement includes a visual display for visually displaying information from said external computer arrangement.

10. A system according to Claim 9 wherein said external computer arrangement includes a database for appropriately scaling visually displayed graphic data depending on the

vehicle being diagnosed, and the electrical parameters of the sensor/actuator connected to the terminal pin or pins being acted upon.

11. A system according to Claim 8 wherein said database includes performance information pertaining to specific sensors and actuators for particular vehicle makes and models.

12. A system according to Claim 1 including means for continually monitoring in real time electronic data entering and/or exiting said onboard computer including actual data associated with said network of sensors and actuators.

13. A system according to Claim 12 wherein said monitoring means includes an external computer arrangement separate from said onboard computer for analyzing said electronic data.

14. A system according to Claim 13 wherein said computer includes means for storing said electronic data into memory, a data base having exemplary data associated with said network of sensors and actuators, and means for comparing the actual data stored in memory with said exemplary data.

15. A system according to Claim 12 including an external computer arrangement separate from said onboard computer forming part of said second means, third means, and said monitoring means for

(a) controlling the operation of said one or more specific actuators independent of said onboard computer,

(b) simulating the operation of said one or more specific sensors independent of the actual operation of the latter sensors, and/or

(c) analyzing said electronic data.

16. A system according to Claim 15 wherein said external computer arrangement includes mans for causing said second, third, and monitoring means to automatically operate in a predetermined way to carry out different predetermined tests on said network of sensors and actuators.

17. A diagnostic system for an automotive vehicle of the type having (i) a network of sensors and actuators for independently sensing and actuating a number of different functions within the vehicle (ii) an onboard computer for monitoring said sensors and controlling the operation of said actuators, and (iii) means for electrically connecting said onboard computer with said sensors and actuators, said connecting means including an auto-side connector having a series of auto-side plug-in terminals respectively connected with said sensors and actuators and a computer-side connector disengageably connectable to said auto-side connector and having corresponding, complementary computer-side plug-in terminals connected to appropriate circuitry within the computer, said diagnostic system comprising:

(a) means for continuously monitoring in real time electronic data entering and exiting said onboard computer including actual data associated with said network of sensors and actuators, said monitoring means including an external computer arrangement separate from said onboard computer for analyzing said electronic data.

18. A system according to Claim 17 wherein said computer arrangement includes means for storing said electronic data into memory, a database having exemplary data associated with said network of sensors and actuators, and means for comparing the actual data stored in memory with said exemplary data.

19. A system according to Claim 17 wherein different vehicle makes and/or models compatible with said system may include different sensors and/or actuators, different onboard computers and/or different arrangement of auto-side and computer-side terminals, and wherein said external computer arrangement includes a database for distinguishing between any of said differences in different vehicle makes and/or models.

20. The system according to Claim 19 wherein said database includes performance information pertaining to specific sensors and actuators for particular vehicle makes and models.

21. The system according to Claim 20 including:

(a) first means for selectively and temporarily disconnecting one or more of said auto-side terminals from corresponding computer-side terminals, whereby to selectively and temporarily disconnect one or more specific sensors and/or actuators from said onboard computer;

(b) second means temporarily connectable with said one or more specific auto-side terminals when the latter are disconnected from their corresponding computer-side terminals for controlling the operation of said one or more actuators independent of said onboard computer; and

(c) third means temporarily connectable with said one or more specific computer-side terminals when the latter are disconnected from their corresponding auto-side terminals for simulating the operation of said one or more specific sensors independent of the actual operation of these latter sensors.

22. A system according to Claim 21 wherein said external computer arrangement forms part of said second and third means for controlling the operation of said one or

more specific actuators independent of said onboard computer and for simulating the operation of said one or more specific sensors independent of the actual operation of these latter sensors.

23. A method of diagnosing an automotive vehicle of the type having (i) a network of sensors and actuators for independently sensing and actuating a number of different functions within the vehicle, (ii) an onboard computer for monitoring said sensors and controlling the operation of said actuators, and (iii) means for electrically connecting said onboard computer with said sensors and actuators, said connecting means including an auto-side connector having a series of auto-side plug-in terminals respectively connected with said sensors and actuators and a computer-side connector disengageably connectable to said auto-side connector and having corresponding, complementary computer-side plug-in terminals connected to appropriate circuitry within the computer, said method comprising the steps:

(a) selectively and temporarily disconnecting one or more of said auto-side terminals from corresponding computer-side terminals, in order to selectively and temporarily disconnect one or more specific sensors and/or actuators from said computer; and

(b) controlling the operation of said one or more specific disconnected actuators independent of said onboard computer and/or simulating the operation of said one or more specific disconnected sensors independent of the actual operation of those sensors.

24. A method according to Claim 23 including the step of continuously monitoring in real time electronic data entering and/or exiting said onboard computer including actual data associated with said network of sensors and actuators.

25. A method according to Claim 24 wherein an external computer arrangement separate from said onboard computer is used to control the operation of said specific actuators, to simulate the operation of said specific sensors, and to continuously monitor the electronic data entering and/or exiting said onboard computer.

26. A method according to Claim 25 wherein different vehicle makes and/or models compatible with said method may include different sensors and/or actuators, different onboard computers and/or a different arrangement of auto-side and computer-side terminals, said method including the step of providing a database in said external computer for distinguishing between any of said differences in said vehicle makes and/or models.

27. A method according to Claim 26 including the step of providing said external computer with a database including performance information pertaining to specific sensors and actuators for particular vehicle makes and/or models.

28. An interactive method for diagnosing an automotive vehicle of the type having (i) a network of sensors and actuators for independently sensing and actuating a number of different functions within the vehicle, (ii) an onboard computer for monitoring said sensors and controlling the operation of said actuators, and (iii) means for electrically connecting said onboard computer with said sensors and actuators, said connecting means including an auto-side connector having a series of auto-side plug-in terminals respectively connected with said sensors and actuators and a computer-side connector disengageably connectable to said auto-side connector and having corresponding, complementary computer-side plug-in terminals connected to appropriate

circuitry within the computer, said method comprising the steps:

(a) continuously monitoring in real time electronic data entering and/or exiting said onboard computer including actual data associated with said sensors and actuators and, using an external computer arrangement separate from said onboard computer, analyzing said electronic data.

29. A method according to Claim 28 including the step of storing electronic data into the memory of said external computer arrangement, providing said external computer with a database having exemplary data associated with said network of sensors and actuators, and comparing the actual data stored in memory with the exemplary data.

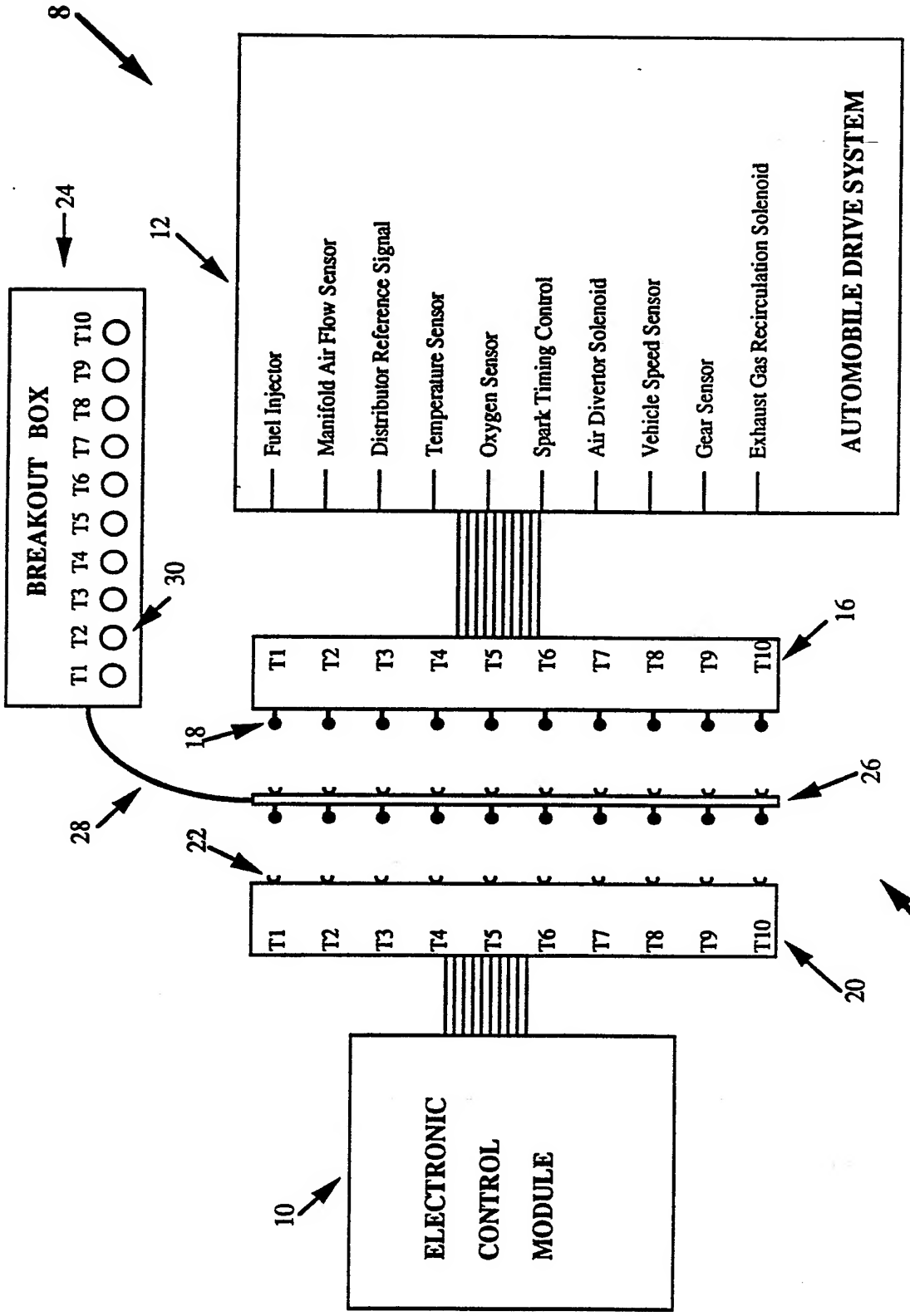

Figure 1 (Prior Art)

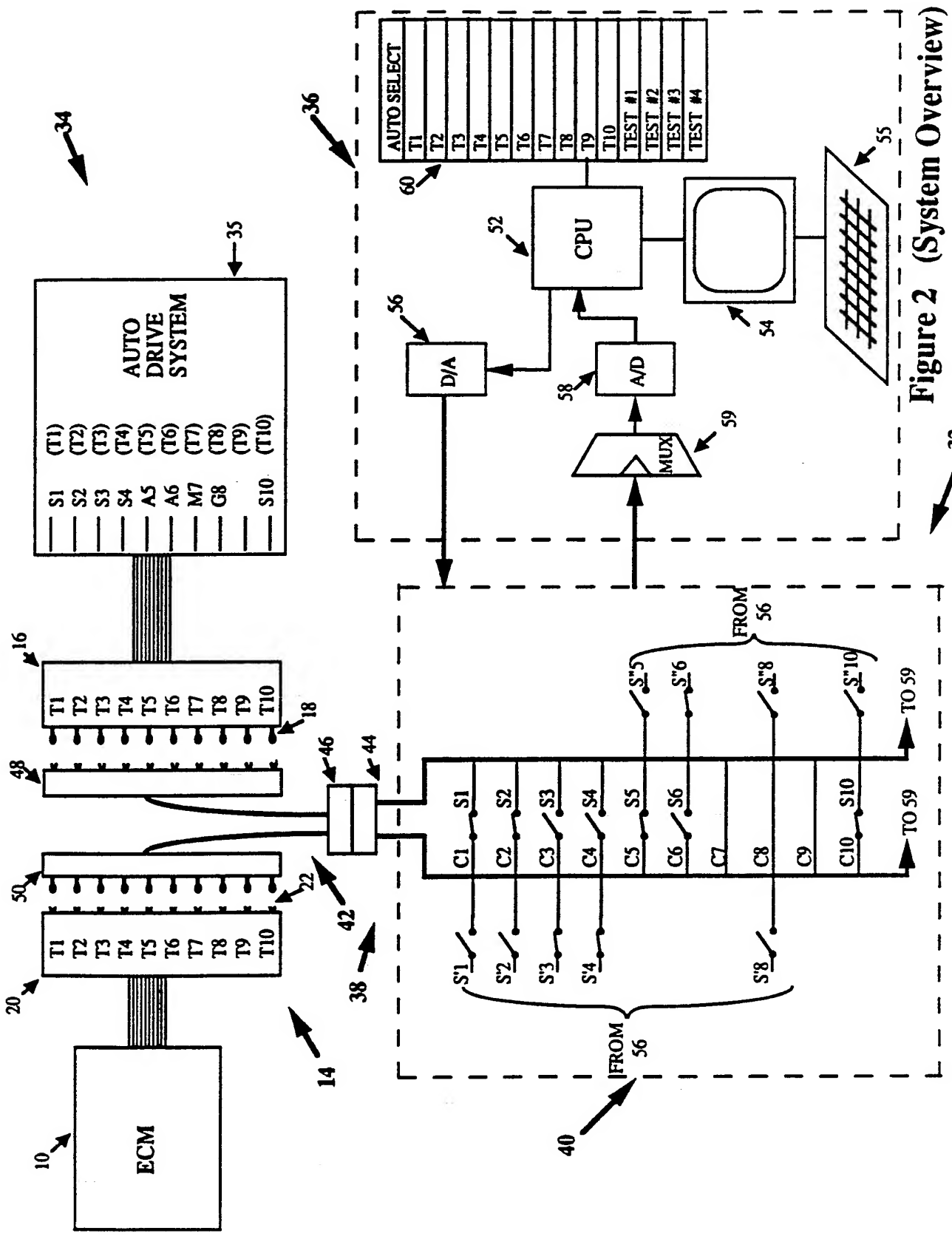

Figure 2 (System Overview)

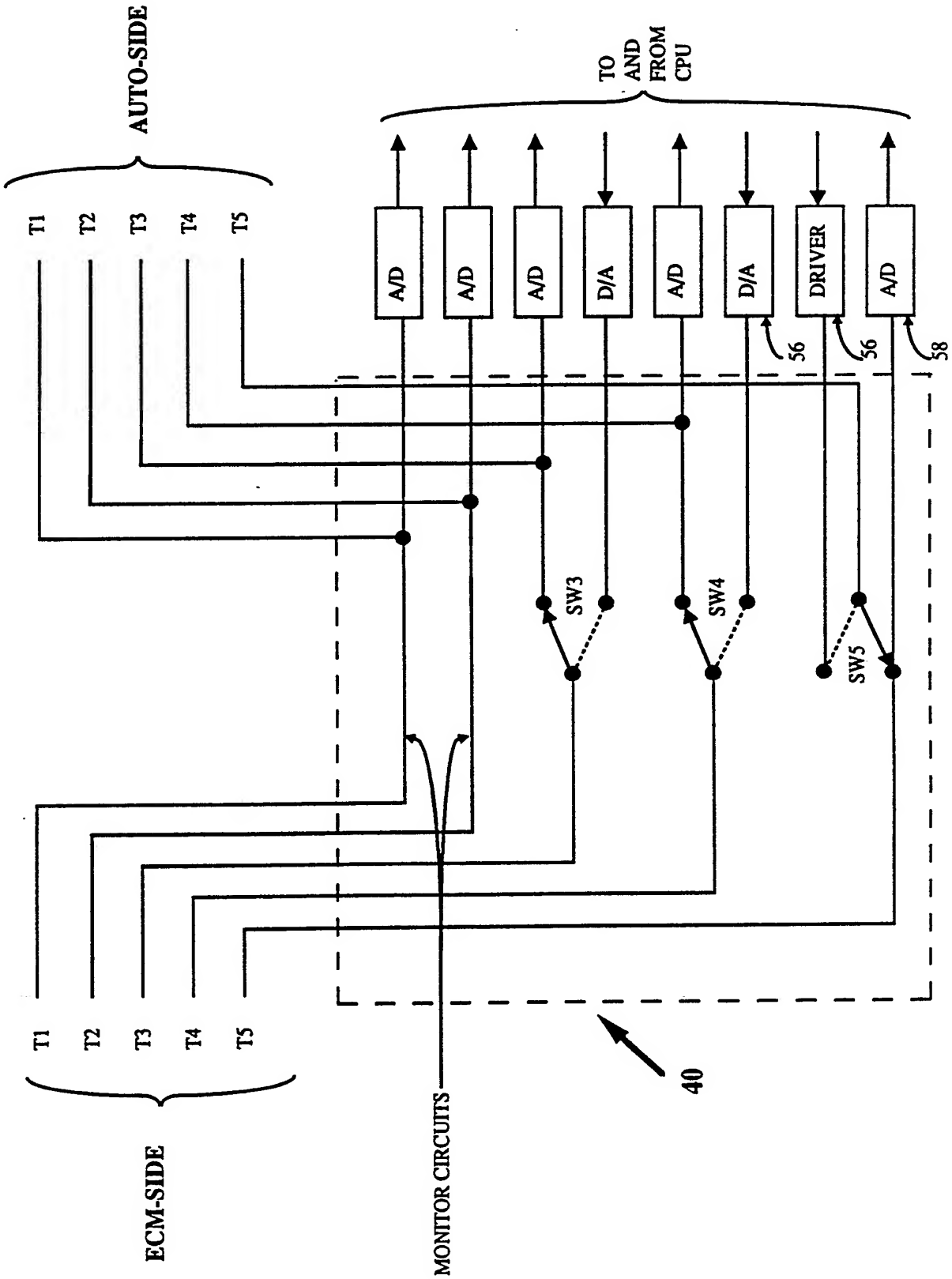

Figure 3 (Bypass Circuitry)

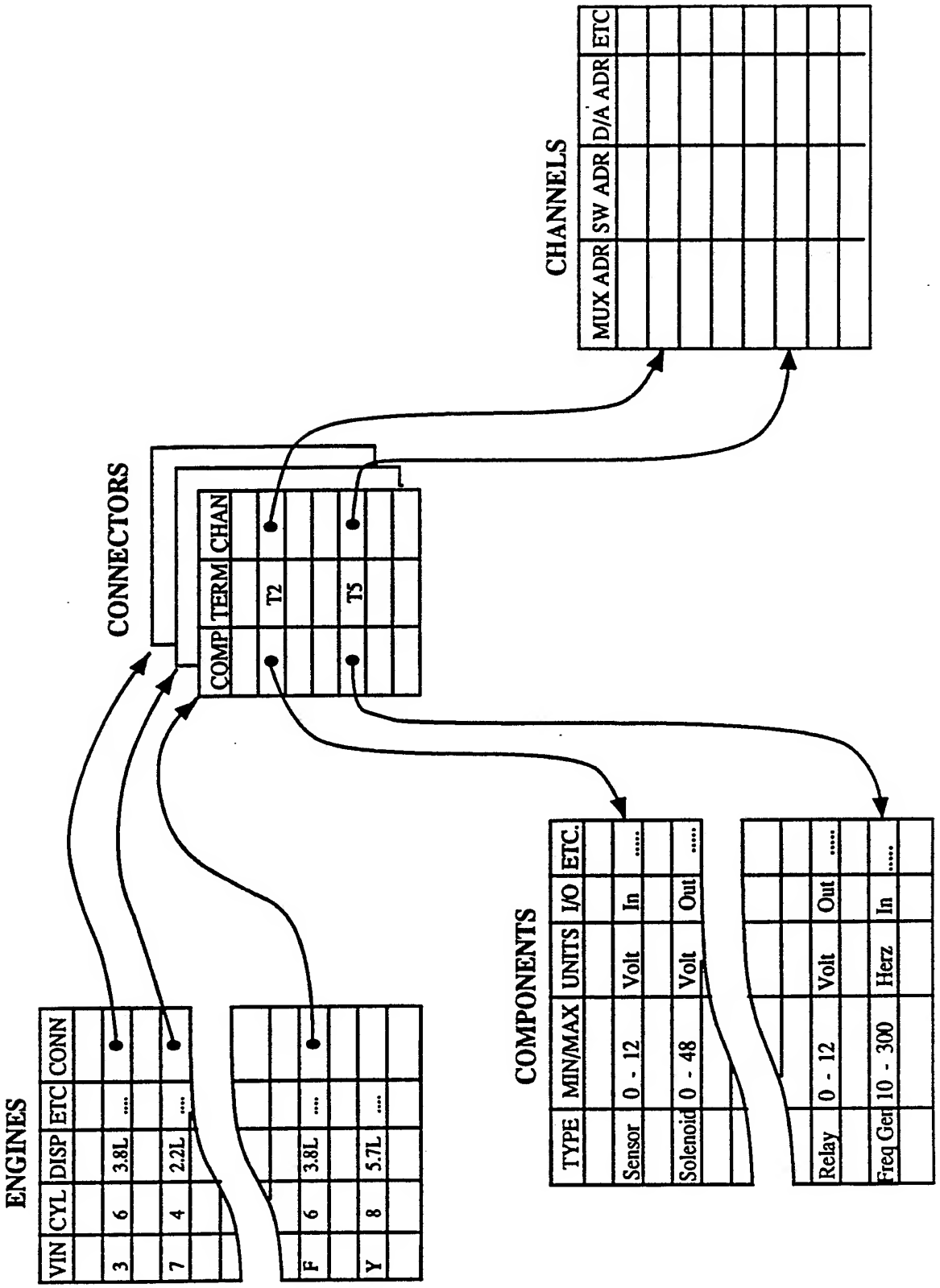

Figure 4 (Database Organization)

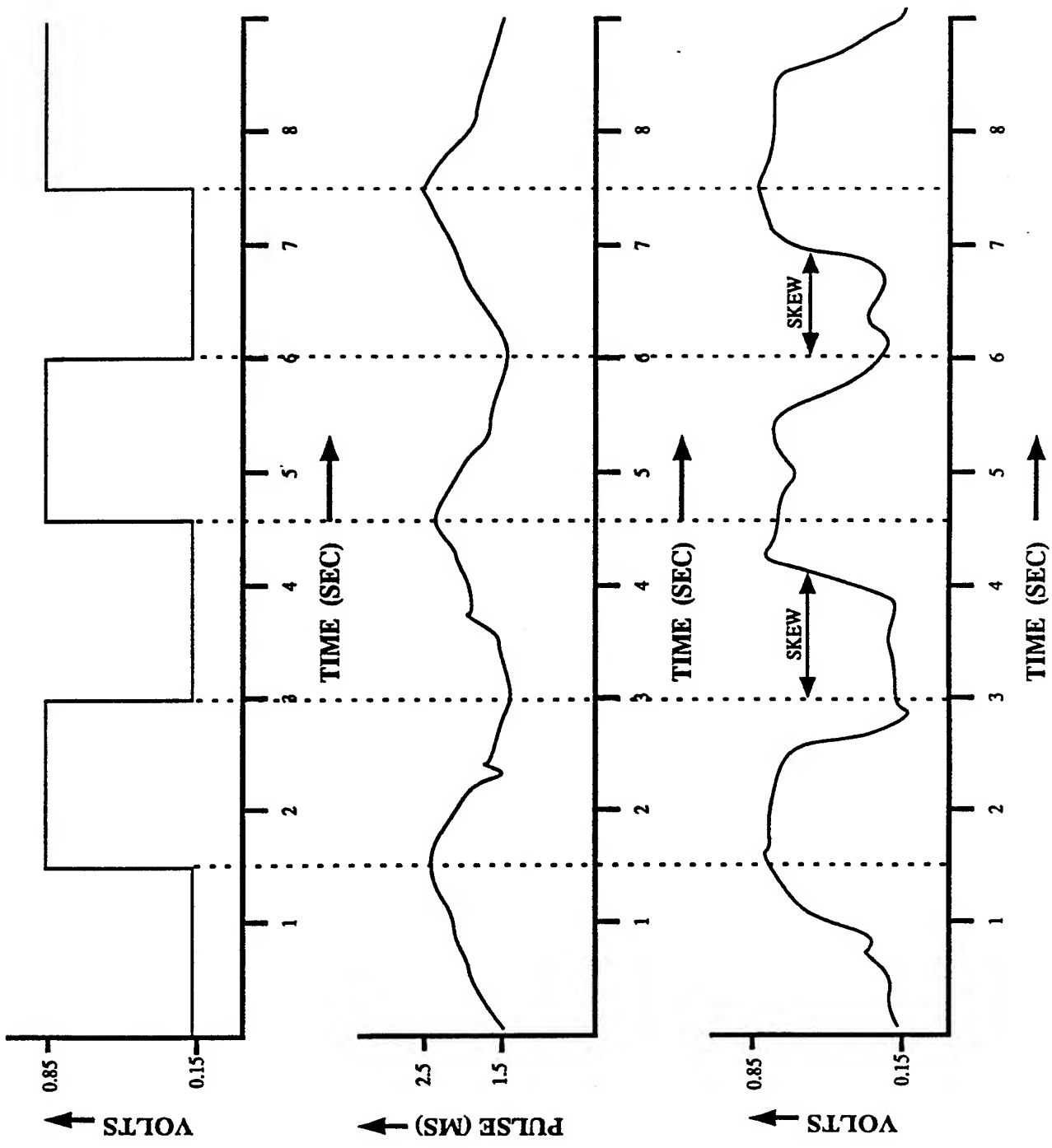

Figure 5 (Oxygen Bypass Test)

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US92/00721

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

U.S.C.L. 364/424.04, 551.01
IPC(5) G06F 15/74

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.C.L.	364/424.03,424.04, 424.01,431.01, 551.01 73/117.2

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	US, A, 4,404,639 (McGuire etal.) 13 September 1983, See Entire Document.	1-29
X	US,A,4,757,463 (Ballou etal.) 12 July 1988, See Figures 1 and 2; and detailed description.	1-29
X	US, A, 4,796,206 (Boscove etal) 03 Jan 1989, See Figures 1 and 2; and detailed description.	1-29
A	US,A, 4,926,330 (Abe etal.) 15 May 1990, See Entire Document.	1-29
AP	US,A, 5,003,479 (Kobayashi etal.) 26 March 1991, See Entire Document.	1-29
X,P	US,A, 5,056,023 (Abe) 08 October 1991, See Entire Document.	1-29
A,P	US,A,5,034,889 (Abe) 23 July 1991, See Entire Document.	1-29

* Special categories of cited documents: [10]
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
26 March 1992	15 MAY 1992
International Searching Authority	**Signature of Authorized Officer**
ISA / US	Thomas G. Black